THE

ELECTRICAL REVIEW.

VOL. XXXIII. NOVEMBER 24, 1893. No. 835

CONTENTS:

	PAGE
Electric Light Mains	547
Arc Lighting.—XII. (*illustrated*)	549
Luminosity, Ozone, and Vacuum Tubes	551
Candle-power of Search Lights	552
Reviews:—La Mort et les Accidents causés par les courants électriques de haute tension (*continued*)	553
Alternating Currents	554
A Practical Guide to the Use of the Edison Phonograph...	554
The Electric Lighting of the Town of Brussels	555
The Primary Action of the Galvanic Current (*continued*) ...	556
Australian Electrical News	557
Legal:—The Medical Battery Company	558
The Elieson Accumulator (English Patent) Syndicate *v.* the Earl of Galloway	558
The Dinner of the Electrical Engineers	559
The City and South London Railway	560
Correspondence:—Elieson Accumulator (English Patent) Syndicate, Limited, *v.* the Earl of Galloway	560
Notes	560
Contracts Open and Closed	563
Business Notices	563
City Notes:—	
Elmore's Patent Copper-Depositing Company	565
Telegraph Construction and Maintenance Company ...	565
Traffic Receipts	565
Share List of Electrical Companies	566
Proceedings of Societies:—	
The Institution of Electrical Engineers (*illustrated*) ...	567
New Patents	573
Abstracts of Published Specifications	573

THE
UNIVERSAL ELECTRICAL DIRECTORY
(J. A. BERLY'S).
ORDER AT ONCE

PRICE 4/- POST FREE.
The Leading Electrical Trades Directory and the Oldest Electrical Directory in the World.

FOR THE 1894 ISSUE.

PRICE 4/- POST FREE.
Fully Revised and Thoroughly Reliable.
Contains a larger amount of commercial Trade Matter than any other Electrical Directory.

H. ALABASTER, GATEHOUSE & CO.,
23, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.

Published every FRIDAY, Price 4d.

The Oldest Weekly Electrical Paper. Established 1872.

TO BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address "AGENCY, LONDON." Code A B C. Telephone No. 517

ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.

The "Electrical Review" is the recognised medium of the Electrical Trades.

SUBSCRIPTION RATES.—In *Great Britain*, Post Free, per Year, 19s. 6d. To all *Foreign Countries* (except those mentioned below), per Year, £1 1s. 8d. *Exceptions.*—Abyssinia, Aden, Borneo, Ceylon, India, Java, Labuan, Mozambique, Penang, Persia (*viâ* Brindisi), Phillipine Islands, Singapore, Zanzibar, to which the rates are: per Year, £1 2s. 10d.

BINDING.—Subscribers' numbers bound, including case, for 2s. 6d. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

READING CASES, to hold from One to Twenty-six Numbers until the Volume is complete for Binding, can now be had from the Publishers, Price 6s., or Free by Post (in Great Britain), 6s. 6d.

FOREIGN AGENTS.—New York: D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 22, Rue de la Banque. *Berlin:* ASHER & Co., 5, Unter den Linden.

Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 23, Paternoster Row, E.C.

ELECTRIC LIGHT MAINS.

IT seems strange that so little has been heard of this most important topic at our Institution meetings, in works treating of electrical distribution, and in the Technical Press. Occasionally a description appears of some new method, or supposed new method, of laying or insulating mains, but the whole subject has not received anything like the attention it deserves.

We do not know who is to blame most for the neglect of what we may justly call the most vital part of electrical distribution plant. If there is any part of a system of electricity supply which ought to be planned and executed in a thoroughly scientific and workmanlike manner, it is the transmission and distribution systems of conductors which carry and deliver the electricity to the consumers.

Perhaps the electric conductor manufacturers are not a little to blame; they do not seem to court criticism as do those who have other portions of an electricity supply system in their hands. Dynamos, engines, boilers, and even the switchboards, have withstood the criticism of years. Innumerable papers, books and articles are to be found on these subjects, and experience of the past 10 years has been accumulated to guide us in dealing with them; yet they are still looked upon with a more critical eye than the supply network of electric light mains. We have endeavoured to ascertain why this is so, and find that it arises from several causes.

Manufacturers have not, in the first place, entered into open discussion of the various types of mains. Secondly, the mains have not attracted the attention of those engineers who, in the past, have done so much to ventilate the questions regarding the central station apparatus. And thirdly, it is only quite recently that the necessity has arisen for underground mains.

Now-a-days it is hardly possible to make mistakes in the choice of engines, boilers and dynamos, and if a mistake is made, it is not a serious matter to rectify; a defective engine, boiler, or dynamo can be easily replaced at a reasonable cost. But the system of mains must be designed for permanency. If a wrong system is adopted and carried out, the mistake becomes a very serious one indeed; it is no trifling matter to remodel a network of electric light supply mains, and it is next to impossible to patch up a defective scheme.

Yet we find in many places a system of low pressure mains has been laid down on entirely new and untried methods apparently without much consideration. When the legal necessity for laying all mains underground was instituted, a new set of problems were presented to the electrical engineer, and in attempting to solve them new schemes were proposed and adopted, and we are now witnessing the results of some of them in practice.

Why electrical engineers should have adopted, without question, new and untried methods of forming and laying

underground conductors is a great mystery, considering how particular they seem to be about less important details in other departments of a distribution system.

It seems to us that the necessity for underground mains coming suddenly with the rapid development of public supplies of electricity has led to the rather hasty adoption of ill-conceived schemes and half worked out systems. It is a fact that the devising of a perfect system of mains is the most pressing problem in the electric light and power industries; so long as the isolated electric light plants were in vogue, the interior wiring was all that one had to consider; but now we must take into account the wiring between the central station and the consumer.

The electricity supply mains in Glasgow and in Manchester have already shown very serious defects; in both places violent explosions have occurred in the electric light conduits. These explosions happen almost invariably in conduits carrying bare copper conductors, or in junction boxes where the conductors and couplings are not insulated by coverings of rubber or G.P.

Explosions can be produced in different ways; when bare copper strip is placed in a cast-iron conduit, such as at Glasgow, and they may take place in junction boxes or manholes in which bare couplings are exposed: very simple experiments can be made to demonstrate this.

The conduits are laid under the footpath near the surface, and a few inches from the gutter, and consist of cast-iron troughs with lids, each about a yard or so in length. Theoretically, these troughs ought to be all jointed together, and the lids cemented on watertight. Practically, it is not possible to make so many joints in metal work laid under the rough inaccurate methods employed, with any approach to reliability. The troughs we have seen as used in Glasgow are not securely bolted together. Any subsidence of the supporting soil, or any pressure applied to such troughs, would readily enough open the joints.

Water enters the conduits and collects in hollows, until it reaches the bare conductors. This water is then decomposed, forming explosive gases, and it is more than probable that the effects described by our Special Commissioner to the World's Fair, Chicago (see page 208, August 25th, 1893), in the experiment showing the heating of a bar of iron, 1 inch thick, in a pail of salt water, takes place in the conduits when the water makes contact with the conductors. There are two ways in which explosions are produced, first by electrolysis, and secondly by forming an arc between the bare conductor and the water.

It is possible to have an explosion brought about by coal gas leaking into the conduits, but not very probable; at any rate, if gas can get in to the conduit, water can also get in, and even if gas gets in it should not be possible to explode it, if the electric mains are properly laid; it requires an electric spark or a red hot conductor to fire coal gas, and any conduits in which an electric spark, a red hot conductor, or an arc is possible, must stand condemned. We are not impressed with the coal gas accumulation theory; it requires more convincing demonstrations than any yet made.

Explosions were at one time common in New York, and were invariably laid to the credit of the gas or steam leakage. The electrical arrangements were supposed to be infallible, although they were the latest and least tried of the three; nevertheless, the electrical engineers had to make improvements to prevent their occurrence.

We have no intention of entering into the case of bare conductors *versus* insulated conductors; that question ought to be raised and thoroughly well threshed out in a paper or papers, and discussions before the scientific societies.

There are many bare copper and conduit systems before us, some of them better than others—at any rate, on paper—but a system of distributing conductors happens to be among those things which may look well on paper, and be altogether impracticable.

While we have years of experience with insulated cables, we are only beginning our practice with bare conductors in conduits. We shall be glad to have the testimony of those engineers who have been in charge of such systems of mains. It is to the distributory mains that we refer. These require to be laid down with a view to their being tapped at innumerable points with ease, and also keeping in view future additions to their carrying capacity. Feeders and transmission mains offer no difficulties whatever, as they run out from the station direct to a given point.

We think the subject is worthy of the close attention of consulting engineers for the reasons already alluded to, for whatever changes time may bring forth in systems of supply, in substituting one kind of current for another, or one class of machinery for another, the network of distributory mains ought to be permanent, and there is no reason why they should be otherwise.

Volatilisation Phenomena in the Electric Arc.

AT a recent meeting of the Paris Academy of Science, Mons. Henri Moissan described his investigations upon certain novel phenomena of fusion and volatilisation produced by means of the heat of the electric arc. He paid particular attention to the behaviour of the metals and their oxides, but that of silicon and carbon were also examined. In the case of carbon he produced from coke exposed for 12 minutes in an arc formed by a current of 380 ampères and 80 volts, thin light translucid plates of a maroon colour by transmitted light. Berthelot has also recognised this new form of carbon. In studying the volatilisation of different metals the following were examined, viz.: copper, silver, platinum, aluminium, tin, gold, iron, manganese, and uranium. A current being used of the above strength, every one of these metals was found capable of volatilisation. Iron and copper only required 350 ampères 70 volts; gold, 360 ampères 70 volts; aluminium, 250 ampères 70 volts; uranium, 350 ampères 75 volts. With the highest strength of current employed in these experiments it was found possible to effect the volatilisation of silicon with ease. In some previous investigations Mons. Moissan has demonstrated the volatility of a large number of metallic oxides, and in the present experiments he has succeeded in proving that such oxides as lime and magnesia, which have hitherto been regarded as infusible, will yield to the heat of the electric arc. He shows that lime volatilises when a current of 350 ampères 70 volts is used, and that magnesia behaves similarly when the current is 360 ampères 80 volts. In short, these experiments show that in the electric arc several non-metals and metals, hitherto regarded as refractory, are volatilised; and it would appear that the electric furnace realises the thermal conditions of remote geological ages. Nothing remains to resist these high temperatures except a series of perfectly crystalline compounds which Mons. Moissan will shortly describe; these are the borides, silicides, and metallic carbides.

ARC LIGHTING.

BY E. TREMLETT CARTER.

(*Continued from page* 503).

[*All rights reserved.*]

XII.

WE have remarked that the 8-L type machine has 12 coils on its armature and three separate commutators. If we number these coils from 1 to 12 successively, then coils 1, 4, 7, and 10 will belong to one commutator, and will be arranged as we have already shown. The next set, namely, 2, 5, 8, and 11 will lag behind the first set by exactly one-twelfth of a revolution, so that if they are similarly combined in another commutator, the fluctuations of voltage on this second commutator will be of the same amplitude, but one-sixth of a period behind the fluctuations on the first commutator. In the same way the set of coils, 3, 6, 9, and 12 may be coupled up to a third commutator, and will produce fluctuations which will be as much out of phase with the second commutator voltage, as the second is out of phase with the first. If now we connect all three commutators in series by suitable connectors attached to the brushes, their voltages will be superposed and added, but the resultant fluctuations will be smaller, owing to the lag which occurs between the individual fluctuations on the three commutators. Plotting the curves on squared paper and adding the ordinates is a good way to determine this. In practice, even with only two commutators, the fluctuations are not sufficient to affect the working of the arc lamps, though with three commutators there is appreciable induction between the line and neighbouring telephone lines, unless the return wire is close to the forward wire. The fluctuation is not, however, sufficiently large to render it inadvisable to place single cables in metal conduits, as there would be but little loss of voltage on account of the damping effect of the neighbouring masses of metal. The coupling of the three-commutator type of dynamo is shown in fig. 36.

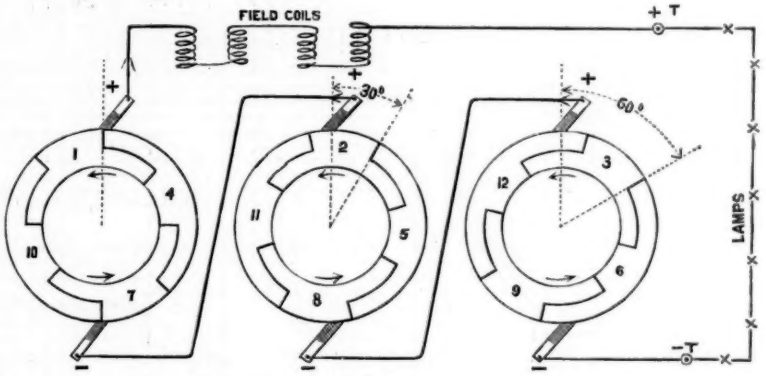


FIG. 36.

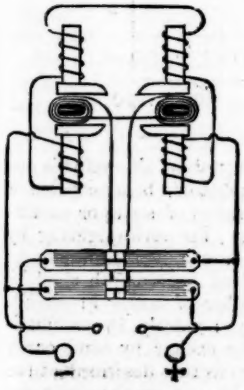


FIG. 37.

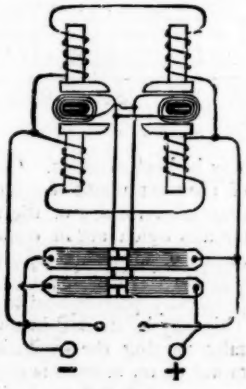


FIG. 38.

This machine is wound for any one of four currents, viz., 10, 12·5, 15 or 20 ampères. Any of the Brush dynamos which are wound for 10 ampères may be altered to give 20 ampères at half the normal voltage, by connecting the pairs of coils in parallel instead of in series on the armature, and by arranging the four field coils in two equal divided circuits instead of all in simple series. This will be better understood by a comparison of fig. 37, which shows an 8-coil machine coupled for 10 ampères; with fig. 38, which shows the same machine arranged for 20 ampères. The connections at the brushes remain unaltered in the two cases.

The brush arc lighting dynamo is constructed in several standard sizes, of which the 5, 6, 7, and 8-L types are the most common. This being the case, it may be necessary to specially adjust the speed of any particular machine to suit the load which it will actually be required to deal with. Thus, for a circuit of 18 arc lamps, it would be necessary to employ a 7 L-type machine. But this machine is capable of running as many as 25 lights, its normal speed being about 900 revolutions per minute. To adjust itself to 18 lights the dynamo must give a proportionately lower E.M.F., but must not be run at a strictly proportionately lower speed because of the "dead turns." In order to facilitate the determination of the proper speed, and thus to enable the engineer to select the proper sizes of pulleys and intermediate gearing between the dynamo and the engine, the Brush Electrical Engineering Company have kindly supplied the author with the following set of working curves, which they use for this purpose. These are shown in fig. 39, and by direct inspection the speed at which any of the ordinary types of machines must be run in order to develop any given E.M.F. can be ascertained. The speed gear should always be designed so that at full load the dynamo gives the right current without using the Brush-Geipel rheostat (see fig. 22); and the rheostat may be depended on to keep the current constant at lower loads. It is not necessary to reduce the speed of the dynamo when the load drops, though it would be more economical to do so if the load is to remain for a long time at a fraction of full value. The curves are for 10 ampère lamps; but if the machine is to give 15 or 20 ampères at a proportionately lower voltage, the values given in the diagram for the voltage, and the number of lamps, must be reduced by one-third and one-half respectively. From these curves it will be seen that to run 18 arcs from a 7-L machine, giving 10 ampères at 50 volts per lamp, it will be necessary to gear the dynamo down to a speed of 660 instead of 900 revolutions per minute.

Allied to the Brush dynamo, though widely differing from it both in construction and internal action, is the well-known and remarkable dynamo generally known as the Thomson-Houston arc lighting machine. So much description of a very full nature has already been published in the ELECTRICAL REVIEW with regard to this dynamo that it will here be unnecessary to enter into any detailed account, and only a brief description with one or two comments upon some important points will be given. Particulars of the construction, action and efficiency of this dynamo are to be found in the ELECTRICAL REVIEW, Vol. xxv., p. 233, and Vol. xxviii., p. 773. The armature consists of three circular coils, drum-wound on a former in such a way as to produce

a spherical figure. These three coils are internally connected in the manner shown in fig. 25 (see ELECTRICAL REVIEW, August 18th), namely, one end of each coil is connected to the corresponding ends of the other two, and the other three ends are connected to three segmental commutator strips. These strips are disposed in a simple cylinder without overlapping, and each strip embraces nearly 120° of arc. The gaps between the strips are filled with air for insulation. The planes of winding of the three coils correspond to the radii through the central points of the commutator strips, and are, therefore, mutually at 120 degrees inclination. There are two pairs of brushes, forming a positive and a negative collector respectively. Each pair is set at full load at a relative angle of 60 degrees; but the leading brushes of one pair are held in a separate rocker to that in which the trailing brushes are held, and the two rockers are capable of a certain amount of rotation round the commutator. This rotation is provided by the constant current regulator, and is so arranged that when the two leading brushes are advanced over the commutator the two trailing brushes are made to recede through three times the angle, the motions of the two rockers, and the adjustments of the two sets of brushes being, therefore, dependent on one another. When the pairs of brushes are at 60 degrees apart, none of the coils remain open-circuited for an appreciable period, each coil gliding into contact with the trailing brush of one pair the instant that it leaves the leading brush of the other pair. When the load falls, however, the rockers are shifted so as to advance the leading brushes and recede the trailing ones; and the effect of this is to put the most active coil in parallel with a less active one for a period which depends upon the amount of shifting, and thus to reduce the terminal voltage of the machine.

Besides the automatic regulator, the dynamo is provided with an auxiliary appliance for maintaining a blast of air over the commutator strips. The proper function of this air blast seems to be imperfectly understood by some writers, as it is asserted that the blast was designed by the inventors of the dynamo for the purpose of blowing out the sparks at the moment of commutation. To quote the words of one of the inventors, Prof. Elihu Thomson, "This is not at all the case and never was, and the air blast was introduced for no other purpose than to make it possible to run the machine steadily at high differences of potential with a commutator which could be freely oiled." It could hardly be disputed, however, that the air blast also tends to minimise sparking during commutation.

13. *Alternators for Series Lighting.*—Almost any form of alternate current generator is capable of being adapted to the conditions of a series circuit, though there is none which is internally self-regulating for the purpose. Most alternators are provided with excitation from a small continuous current machine; and it is possible, by regulating the strength of the exciting current, to vary the E.M.F. of the alternator at will, even though the speed of the machine may be kept constant. On this account an alternator is one of the most pliant of electrical generators, being capable of regulation for any of the various forms of series or parallel circuits which are in common use. For series lighting by means of a constant alternating current, it is necessary to regulate the exciting current so that its strength shall be practically proportional to the number of lamps in circuit. This may be effected in several ways: namely, by automatically varying the excitation of the exciter by hand or by means of an automatic device, such as that described at the commencement of the last section, by varying the resistance in the exciting circuit, by interposing a counter electromotive force in the exciting circuit, and by varying the speed of the exciter. Of these, the first is the most common and probably the most efficient and reliable; and while in America more confidence is placed in automatic devices, in this country the regulation of the field is mostly hand controlled.

From the generator point of view, arc lighting by means

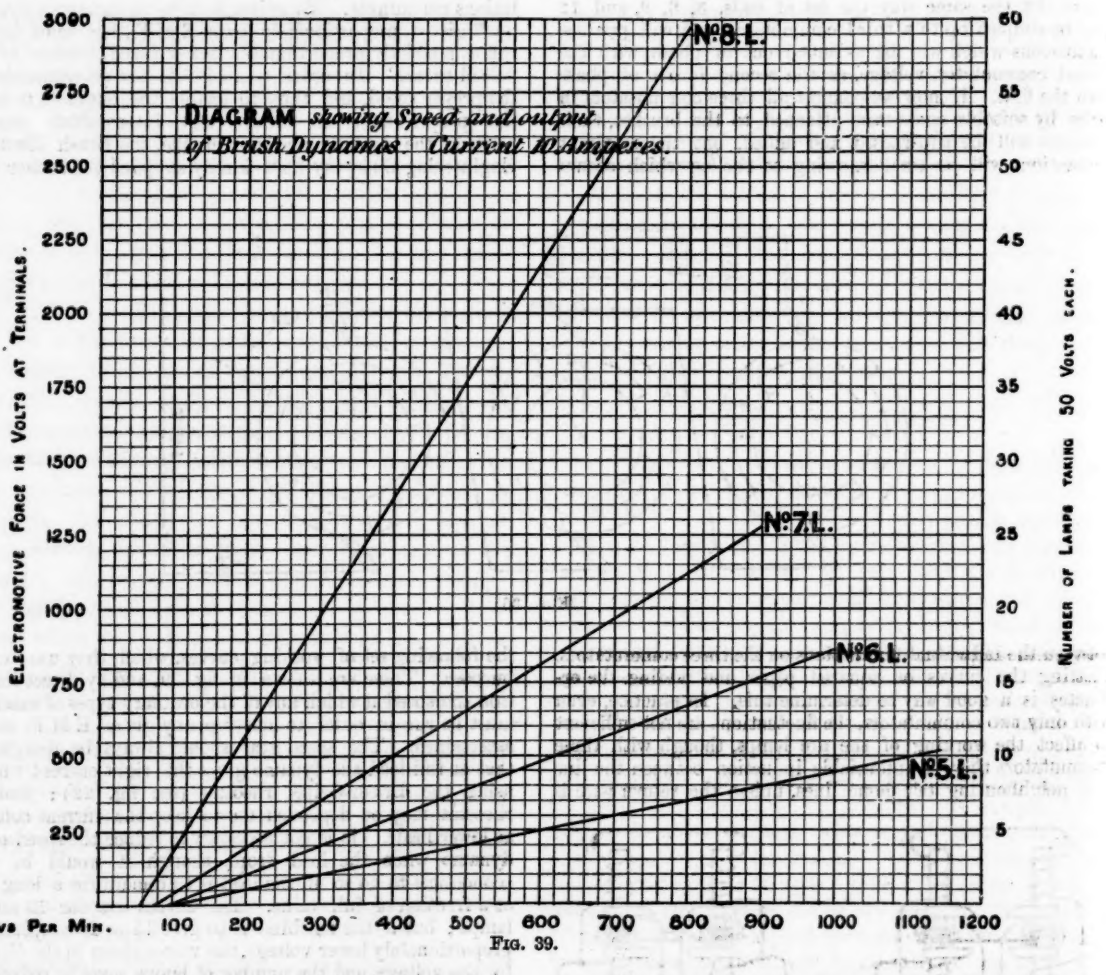


FIG. 39.

of alternating currents has the following advantages: the difficulties of sparking and flashing over at the brushes are entirely obviated, and even the necessity for brushes of any kind does not always arise; the limits of voltage are, therefore, higher, and consequently the lamp capacity of the machine is greater than with continuous currents; and machines may be conveniently built to run at lower speeds and direct-coupled to the engines, giving a higher generating efficiency than with high-speed geared machines. On the other hand, the plant efficiency of alternators is lower than that of continuous current machines, and it is not possible to combine two alternators in series so as to add their voltages.

There are few, if any, of the well-known types of alternators which are not being employed for series lighting; but the machine which is probably doing more work of this kind than any other, is the Westinghouse alternator, a machine very largely employed in the United States. In this country the Mordey alternator is largely employed for arc lighting in several important towns.

The Westinghouse alternator is designed both for series-direct lighting and for series transformer lighting. In the former system it is generally designed to give 10 ampères, and machines for this work are built to run any number of lamps up to 60, with a terminal voltage not exceeding 3,000 volts. When it is necessary to run a greater number of lamps on one generator, the transformer system is adopted, and the generator is designed to give either 20 or 30 ampères. The 30-ampère machines have a capacity up to 240 lights per machine, at a terminal voltage of 4,000 volts. With the 20 and 30-ampère alternators, the lamps are placed on the secondary circuits of transformers, which reduce the current in the ratios of 2 : 1 and 3 : 1 respectively, correspondingly raising the secondary voltage.

(To be continued.)

LUMINOSITY, OZONE, AND VACUUM TUBES.

BY E. ANDREOLI.

THE phenomena of phosphorescence, luminosity or light produced by electricity in vacuum tubes, containing or not containing electrodes, have been in this country and abroad the object of researches and experiments by scientists who have thoroughly investigated the subject and demonstrated almost everything from a theoretical as well as from a practical point of view, in connection with the discharge and its effect as luminosity, striæ, sensitive or not sensitive state, &c., &c. In all cases, however, the spark which rendered luminous the tubes containing electrodes was the disruptive discharge. In every tube there were two electrodes, sealed at the two ends, and thus the phenomena was entirely confined to more or less light generated between the poles inside the sealed glass and accompanied by a development of heat.

We all know that luminous rings are produced in exhausted bulbs and tubes by the electrostatic action of wires surrounding them. It is also a very well known fact that if the terminal of an incandescent lamp is placed on, or near to one of the terminals of the secondary circuit of an ordinary Ruhmkorff coil, the lamp becomes faintly luminous, and shows a crepuscular white or pale violet hue.

It struck me that by surrounding the glass with a helix made of small fret saws or of fine serrated wires, it would be possible to generate luminosity in an incandescent lamp or a vacuum tube, or a tube containing rarefied gases, and, at the same time, a silent discharge on the outer surface of the glass, followed by an abundant production of ozone. The result fulfilled my expectations, and either by means of an ordinary Ruhmkorff coil or of a transformer, I obtained beautiful displays of colour and luminosity simultaneously with ozone, by means of exhausted tubes containing an iron or other metal wire or rod sealed in the glass and acting as an electrode.

I submitted a vacuum tube about 15 inches long and 2 inches diameter, to the action of a transformer giving 8 to 10,000 volts. The central wire which was sealed in the glass at the two ends of the tube, was made of iron, and its diameter was about $\frac{1}{3}$th inch. The tube was surrounded by a spiral, made of serrated wire, 2 yards long, on each point of which, when the current passed, a violet glow appeared, accompanied by a slight buzzing sound and a very strong smell of ozone. The inside of the tube was entirely illuminated by a violet light which spread between the ends of the spiral, but did not extend further. On the rod or wire in the centre of the tube, I noticed some bright white spots, such as the electric arc produces on particles of metal; these incandescent scintillating points were always opposite a turn of the external wire, but not between two turns of wire.

I have frequently continued this experiment for more than an hour, and I observed that the glass at the end of the experiment does not become hot, and that the external armature of serrated wire is merely warm. Of course, the absence of heat is of great importance in an ozoniser, and the production of ozone takes place in this way, not only in the open, but in the fresh air. I must add that I do not know of any other example of luminosity caused in a tube by the electric discharge and which is not accompanied by considerable heat. I may be mistaken, but as far as I can judge from my careful perusal of all the papers and books published on the phosphorescence or luminous effects caused by the electric spark passing through rarefied gases, I have never found, in one single instance, that use had been made of the silent discharge around vacuum tubes rendered luminous, and persons interested in electrostatic induction questions will, perhaps, find some novelty in my simultaneous production of ozone around a vacuum tube containing an electrode concurrently with a more or less intense luminosity inside the tube. This phenomenon cannot be absolutely compared with the ordinary condenser consisting of two electrodes separated by a dielectric, and respectively connected with the two poles of an induction coil, between which the effluvia show their violet glow. The electrodes which I use inside the vacuum tube are generally very thin rods or wires. Sometimes I use an incandescent lamp, and in all cases, therefore, in contradistinction to the usual ozonisers, one of the electrodes only has a large surface, whilst the inner one is small and relatively at a great distance from the outer one.

If the tube or bulb is broken or cracked, the luminosity disappears and no ozone is produced; therefore these luminous ozonising tubes cannot be positively assimilated to the condensers which have been used up to the present as generators of ozone. Nor can it be asserted that the luminosity is due to the reflection of the violet glow of the silent discharge which, apparently, illuminates the gaseous mass in the tube, since, when vacuum tubes containing an electrode but are not provided with an external electrode, are put in contact with one or several similar tubes, each being respectively connected with one pole of the induction coil, they all become illuminated and ozone is freely evolved from the glass itself. In these ozone tubes, there are two different illuminations; first an irradiation which fills up the tube in the centre, while the internal wire or rod remains dark, and second, a silent discharge showing a violet glow on each of the points of the serrated wires which surround the tube spirally or longitudinally, but at a very small distance from the glass. I intend to continue experiments on tubes containing different rarefied gases, and also various sorts and shapes of internal electrodes. The shape of these electrodes is not immaterial for obtaining a greater or smaller yield of ozone. For instance, in small tubes, 1 inch diameter and 6 inches long, worked by a coil and an accumulator, there is more ozone generated when the internal electrode is made of three or four serrated wires or fret saws soldered together, and the points of which radiate and face the glass.

Spottiswoode said that "the discharge in a vacuum tube does not differ essentially from that in air and in other gases at ordinary atmospheric pressure, and that it cannot be considered as a current in the ordinary acceptation of the terms, but must be of the nature of a disruptive discharge, the molecules of the gas acting as carriers of electrification. The gases receive impulses in two directions at right angles to each other, that of the negative being the more continuous of the two. Metal is frequently carried from the terminals and is deposited on the inside of the tube." The case which I describe is quite different, as I have no disruptive discharge in my tubes; the gas does not receive impulses at right angles; the electrodes are separated by the glass of the tube, the inside of which becomes luminous, and by the thin layer

of air outside, which is spotted by thousands of violet glowing lights emitted from the points of the second electrode.

While working some incandescent lamps in this way, I noticed that after breaking the circuit there was a kind of luminous wave inside the bulb, which brightened again for a moment when the lamp was touched or blown upon; but these are facts known especially by the experiments described in the *Philosophical Transactions* (1879), by Messrs. Spottiswoode and Fletcher Moulton.

In no case have I seen any brilliant luminosity over my external wires, such as has recently been described in a contemporary, owing, as it was explained, "to the electric stress in the tube being greatest close to the wire where the magnetic induction is the strongest." The luminosity on my wire is always the soft glow of the effluvia.

The rate of the silent discharge from the points of the external electrode is considerable, and the luminosity of the inside of the tube is constant. When the glass is only surrounded by serrated wire in its middle part, the two ends do not show the usual violet tinge, the light being concentrated in the part of the tube surrounded by the wire. If an incandescent lamp is used, as soon as the current passes the carbon filament is violently agitated and its vibrations are in proportion with the frequency of the apparatus. The filament never gets incandescent or even red, and the glass, even after it has been kept luminous for a considerable time, does not get hot. A lamp, or tube, will remain dark if its vacuum is destroyed. There is no luminosity in a non-exhausted tube; there is less in an imperfectly exhausted than in a well exhausted tube. The production of ozone in most cases is proportionate to the luminosity.

The surrounding of the tubes by a metallic point-bearing spiral is not absolutely necessary, and the same effects are obtained when the tubes are placed on or under two rows of serrated wires, or, better still, between two such grids; the tubes then become very bright, and the evolution of ozone is extremely strong.

The experiment is so simple that it is unnecessary for us to give the explanation of this formation of ozone, and, at the same time, of the internal luminosity of the tube. It would be premature for me to enter into more detailed considerations, as there are several questions to examine experimentally, and I have not had yet time to study and compare results which different apparatus may afford under given conditions of pressure, exhaustion, dimensions and shape, number of points, distance between the electrodes, nature of the electrodes, &c.

Under certain circumstances, which I will specify in due course, the formation of ozone is much slower, and its smell very faint, while the glimmering of the gaseous mass is much brighter. I do not wish to exaggerate the importance of these phenomena; on the contrary they must be taken for what they are worth, but, shall I be taxed with presumption, if I venture to say that, perhaps, there is something beyond this abundant production of ozone around a tube rendered luminous, and that if, by certain means, it is possible to reduce the quantity of ozone which otherwise would be generated, it may not be impracticable to increase the luminosity emitted by the gases in a sealed tube, or lamp, encircled by an electrode of an appropriate nature and shape?

Many people think that what is wanted in a lamp is a very high degree of incandescence of the electrode, but as Tesla says: "There they are mistaken, because the high incandescence of the button is a necessary evil, while what is really wanted is the high incandescence of the gas surrounding the button. In other words, the problem in such a lamp is to bring a mass of gas to the highest possible incandescence."

In my sealed glass tubes the electro-dynamic inductive action produces luminous effects only without hardly any heating of either the electrode or the glass. There is a great difference between this luminosity or phosphorescence of my tubes and the light or incandescence; but is there anything unreasonable in the assumption that the external electrode on which the silent discharge takes place may also be utilised for minor lighting purposes?

There are things in the domain of electricity which are now producing important results, the beginnings of which have been much less remarkable than those of luminous vacuum tubes producing ozone. These facts remind us of the conjecture of Grove who said:—"Whether gases at all conduct electricity, properly speaking, or whether the transmission is not always, by the disruptive discharge, the discharge by convection, or something clearly analogous, is perhaps a doubtful question." It has been stated by Tesla to explain how luminous discharges take place in electrodeless vacuum tubes through coils surrounding them, that it must be attributed to the electrostatic action of the surrounding wire, rather than to the rapidly varying magnetic induction through the rarefied gases. Prof. Ayrton, on the contrary, thinks that varying magnetic induction is the chief cause of the luminous rings, but that a superposed electrostatic field greatly assists the production of luminosity.

In the present case, the glass tube contains an electrode, and is surrounded by another electrode so that magnetic induction and superposition of an electrostatic field are concomitant. No vacuum or imperfect vacuum, no luminosity or little luminosity, and no ozone or little ozone. No serrated wire or point bearing electrode, but, instead, a different electrode around the tube, no ozone or hardly any ozone, and an increase of luminosity.

CANDLE-POWER OF SEARCH LIGHTS.*

By CHARLES P. STEINMETZ.

In last week's Digest of Electrical Literature I read a statement on the candle-power of search lights which seems to me to be misleading. The mistake made is in the assumption that the beam of light of a search light consists of parallel rays. If this were the case, it would be wrong indeed to speak of a candle-power of search light, since the illuminating power would be the same at any distance, and the candle-power, in the usual definition, infinite.

The light rays of a search light are parallel, however, only when reflected from a mathematically true parabolic surface, and emanating from a mathematical point coinciding absolutely with the focus of the parabola.

In reality the source of light is an area of finite extension, the crater of the arc and the reflected rays are in consequence thereof divergent, and the angle of divergence is equal to the angle under which the crater is seen from the centre of the reflector, as a simple reasoning shows.

If now, seen from the crater, the reflector subtends an angle of, say, 120°, the whole volume of light given out by the crater within this spherical angle is reflected within the narrow angle of divergence of the reflected beam of, say, 2°. That means the light is concentrated by the contraction of the illuminated area in the proportion of the squares of the angles 120° and 2°, that is 3,600 times, and consequently neglecting losses of light in reflection, the intensity of the reflected beam compared with the direct light is increased 3,600-fold. This value is called the multiplying factor of the reflector, and some reasoning shows that it is equal to the ratio of the reflector area to the crater area; that is, in other words, in the reflected beam the light intensity is the same as that of a crater whose diameter is equal to the diameter of the reflector. The rule of estimating the candle-power of a search light, mentioned in the Digest is, therefore, not an absurd assumption, but based on correct theoretical reasoning; and, as I may add, well proved by photometric tests.

Assuming the candle-power of the direct arc as averaging 60,000 in the angle subtended by the reflector, and 3,600 as multiplying factor, we get the candle-power of the reflected beam, as $66{,}000 \times 3{,}600 = 216$ million candles. Such are the intensities of our modern search lights.

Since the beam of a search light consists of divergent rays, the law of inverse squares holds for the search light, just as well as for any other source of light, and with the same limitation; that is, that this law is the law of distribution from a mathematical point, and therefore holds true for any source of light only in a distance sufficiently large to permit the consideration of the source of light as a point. This distance is greater, indeed, with a search light than with an incandescent lamp.

* New York *Electrical World*.

REVIEWS.

La Mort et les Accidents causés par les courants électriques de haute tension. Par le Docteur FRANCIS BIRAUD, Médecin stagiaire au Val-de-Grâce. A. Stork, Lyon; G. Masson, Paris.

(*Continued from page* 529.)

The measurements made by Mr. A. E. Kennelly on the occasion of the electrocution of MacElvaine, are of interest, having being determined with great care. When the first contact was made, the resistance fell from 800 to 516 ohms in 50 seconds. During the second contact a constant resistance of 214 ohms was recorded. The contact was made at each hand by immersing it in a leaden vessel containing a tepid solution of brine. The second contact was made from the head to the calf of one leg. The description of this execution, or rather electrocution, is not pleasant reading. There is little doubt that in this case the victim was not killed by the first shock, but only rendered unconscious. In fact there appears to be some doubt as to whether death by electrocution is really due to the action of the current or to the post-mortem examination, as the law provides that the post-mortem shall be made immediately after the execution. The experiments on high frequency, by Tesla, do not tend to fix one's ideas as to the exact power of the electric current to cause death. It would appear that if the frequency is sufficiently high, considerable currents may with absolute impunity be passed through the body, that is to say not only without danger, but without pain.

The determination of the resistance of the body would appear to offer difficulties which are not easily overcome. Weiss has shown by experiment that the resistance of the tissues decreases with the increase of the electromotive force. The experience gained in the electrocution of MacElvaine seems to point to a decrease in the resistance of the tissues, due to the passage of the current, so that with a constant electromotive force it might be possible to bring into existence a current density sufficient to cause death if the duration of the contact is sufficiently long. According to D'Arsonval the physiological effects of stimulation of nerves and muscles, as well as effects producing a fatal result, are governed by the law of the variation of the electromotive force with the time. According to Weiss, the variation of current density with the time is the principal function to be studied. Be this as it may, there seems little doubt that the form of the wave exercises a very considerable influence upon the effects produced.

The experiments of Tesla and of Swinton prove that a current of electricity of a certain wave form, and where the E.M.F. is many thousand volts and the current density sufficiently small, may be sent through a human being without inflicting any injury whatsoever. But these same experiments point to the fact that under certain conditions of E.M.F. and current density and frequency of alternation, a fatal effect would be produced. Dr. Biraud suggests that the maximum effect is caused by a continuous current at several thousand volts, or an alternate current of 150 volts where the current density is considerable and the frequency low.

This is certainly a new suggestion, and, if true, opens another source of danger to the use of alternate current. Dr. Biraud does not suggest what the frequency should be, but from our experience of shocks received from an alternate current at 100 volts at a frequency of 200 per second, it would certainly appear that the frequency at which 150 volts alternating becomes dangerous or fatal must be very considerably below this, and, therefore, below the figure which has been found in practice to be the most economical from the point of view of distribution; but this view appears to be untenable if judged according to further experiments which will be referred to later.

D'Arsonval and Korthals, among others, have attempted to frame a hypothesis to explain the reason of the innocuity of currents of very high frequency. D'Arsonval suggests two reasons, one purely physical and the other purely physiological. As to the first, he argues that alternate currents of high frequency do not obey Ohm's law. Such currents flow on the surface of a conductor, and the depth of the conductor taken up in the passage of the current, is less in proportion as the frequency is greater. Now, pushing this to a logical conclusion, when the frequency is sufficiently high, the current will flow over the surface of the body, and will not penetrate into the nerves and muscles.

D'Arsonval's other hypothesis is simply that the nerve tissues are incapable of appreciating the effect of an electric current whose frequency is sufficiently high, as the nerves of the ear and eye are insensible to vibrations exceeding a certain value per second.

Korthals's hypothesis is based upon the electrostatic capacity of the body, in virtue of which he suggests the effective potential of the body may be reduced to a small fraction of that of the source of electric energy. According to Korthals's reasoning an electrostatic capacity of 0·118 microfarad is sufficient to reduce the potential at the points of contact with the body from 100,000 volts to 100 volts, the frequency assumed being 300,000 from a Ruhmkorff coil. Korthals's figures agree with those obtained in Tesla's experiments, but when Korthals's formulas are applied to some of D'Arsonval's experiments, we find again a serious discrepancy which seems to show that the whole question of the "how" of an electric shock to the human body becomes more complex as observations multiply.

The author discusses the effect of periodic currents of single and multi-phase, and cites at some length the results of some experiments made by Mr. Kennelly on various animals at the Columbia College. From these experiments it would seem that with a frequency of 11 to 68 per second the electromotive force necessary to produce death is considerably higher than when a frequency of 200 to 288 was employed. The duration of the contact does not vary in any proportion to the electromotive force, and, indeed, the conditions and the results vary so widely that it is impossible to draw any other than the most general conclusions. At the same time it is more than probable that the duration of contact is a most important factor. D'Arsonval suggests that a fatal result may be caused by an alternate current, where the electromotive force is comparatively low, in the following manner:—The muscular contractions caused by an electric discharge through a human being produce a development of heat so exaggerated in amount, as compared with the heat production caused by the normal physiological processes, that death ensues, owing to the incapacity of the body to resist this extra heat production, and owing to the consequent coagulation of the myosin, and to other chemico-physiological changes in the tissues. This opinion has been verified by D'Arsonval in an experiment on an animal immersed in a cold water bath. Under these conditions the animal was not injured by the passage of a current which, under ordinary circumstances, would ultimately have caused death. Leaving the speculative side of the question, we come to what may be termed the practical side. This is, perhaps, the more interesting and important, although, perhaps, not the more pleasant portion of Dr. Biraud's work. We hear of accidents due to electricity at various times and in various parts, but we are seldom in a position to draw any useful conclusions from these occurrences, owing to the want of careful and impartial observation or recitation of the facts of the case; it is, therefore, impossible to frame any reliable rules for the guidance of those intimately connected with the generation and distribution of electrical energy at a high electromotive force. Moreover, up to the present, there has been little or no inquiry into the pathological aspect of such cases. That accidents due to electrical effects open up a new branch of pathology is, of course, undisputed, and a careful study of the signs exhibited by a victim of electrical action are of immense importance. In the first instance, one is naturally led to ask: "What is it that causes death?" that is to say, what effects are produced by the passage of the current (if it *does* pass) through the body, to cause a suspension, temporary or permanent, of the vital functions?

In the paragraph on the "Mechanism of Death by Electricity," the author calls attention to the two modes in which death may be produced, viz.:—(*a*) *Directly*, that is, by the disruptive action of the current destroying the tissues mechanically. (*b*) *Reflexly*, that is, bringing about inhibitory effects by acting on the nervous centres.

He quotes D'Arsonval's experiments, in which the latter shows that a static discharge will produce a disintegrating action when its energy amounts to about 3 kilogrammetres. If this discharge reaches the medulla, the suspension of the

functions of this portion of the central nervous system can be imagined as the result of a dislocation, so to speak, of its anatomical elements. On the other hand, supposing the strength of current to be insufficient to bring about these mechanical changes, then those inhibitory phenomena are produced which were obtained by Brown Séquard on mechanically irritating the medulla, that is to say, respiratory and cardiac inhibition, sub-pleural ecchymosis, pulmonary emphysema, paralysis, &c. This mode of action appears to be the one that obtains in accidents caused by electric currents.

He distinguishes, therefore, these two forms of death, calling the first "*fulguration*," and the second "*sidération*."

D'Arsonval then is an advocate of a reflex death by inhibition through the medulla, whereas Edward Tatum maintains that the heart itself is concerned in such a death, and that any external inhibitory mechanism plays a very insignificant *rôle* in it, if, indeed, it plays any at all. And Tatum arrives at this conclusion as a result of some experiments on dogs that had been atropinised and curarised, and also on others in which he had divided the pneumogastric.

Now, atropine and curari paralyse the inhibitory fibres of the pneumogastric; and Tatum seems to conclude that because death took place in the ordinary way without the assistance of the inhibitory route, that, therefore, the latter is superfluous.

The author does not consider the experiments which led Tatum to formulate his dictum to be absolutely demonstrative. We quite agree. It seems to us that the comparatively recent investigations of Gaskell opens up a vast field of research in the connection between the sympathetic and the central nervous systems. We know that in the dog, cardiac nerves actually proceed to the heart from the anterior roots of the upper thoracic nerves *viâ* the annulus of vieusseus; it is true that it has been demonstrated that these are cardio-accelerator fibres; but we are not yet in a position to positively deny the existence of inhibitory fibres from the same source, and of their possible connection with the cardiac centre in the medulla. Should this be proved to be the case, the pneumogastric inhibitory route might be dispensed with on an emergency.

The author gives a plate representing some ecchymosis in the medulla which were found, post-mortem, after the "electrocution" of Wm. Kemmler in America. Dr. McDonald is quoted as follows:—"Capillary hæmorrhages were found in the floor of the fourth ventricle, also in the third ventricle and the anterior portion of the lateral ventricle. The perivascular spaces seemed to be distended with serum and blood."

Microscopically it was found that these spots consisted of little masses of extravasated red corpuscles, situated mostly in the perivascular spaces immediately beneath the ependyma.

In the drawing given, one of these hæmorrhages is seen to be situated on a level with the nucleus of the pneumogastric, and others, smaller ones, on a level with the nucleus of the hypoglossal.

It is, of course, difficult to explain the mode of production of these hæmorrhages. The author believes their presence cannot be of capital importance as they do not appear to be constant.

(*To be continued.*)

Alternating Currents: An Analytical and Graphical Treatment for Students and Engineers. By FREDERICK BEDELL, Ph.D., and ALBERT CUSHING CREHORE, Ph.D. Second edition. New York: W. J. Johnston & Co., Limited.

The appearance of the second edition of this work so soon after the first shows that it must have been appreciated by the class of readers for whom it was intended.

The book is divided into two parts; in the first the analytical system is entirely employed, and, in the second, many of the same problems are treated graphically, in addition to which others, such as the distribution of currents in resistances, self-inductances and capacities in series and parallel, of which the analytical treatment would be very complicated, are here solved by the extended application of the graphical principles given for the simpler cases. In Part I., Chapter I. is introductory and deals with the usual elementary principles and definitions of magnetic poles, lines of force, the effect of altering the magnetic induction through a circuit, &c. The treatment is good and clear, and the authors state in the preface that this chapter is put in so that anyone without previous knowledge of the theory of electricity and magnetism can understand the book. It is, however, we think, rather unlikely that anyone who was not fairly well acquainted with the general theory of electricity and magnetism would care to study the rather intricate subject of alternate currents. Chapter II. gives a very clear description of harmonic functions.

After these two preliminary chapters the authors plunge into alternating current circuits, commencing with the simpler ones containing resistance and self-inductance only, then those with resistance and capacity only, and, finally, treating those containing all three.

The plan of treatment is the same throughout; first the differential equation is obtained, then its general solution when the E.M.F. is some function of the time, and, finally, the particular solutions for E.M.Fs. which are various functions of the time. The particular cases taken are (1) E.M.F. suddenly removed; (2) E.M.F. suddenly introduced; (3) simple harmonic E.M.F.; (4) any periodic E.M.F. In addition to obtaining the particular solutions from the general one, the authors obtain them also from the original differential equations. In the case of a simple harmonic E.M.F. there is a much shorter method of obtaining a particular solution to the differential equation than either of the ones given in this book, viz., assuming the current as a simple sine function of the time.

The authors treat very fully the exponential terms which occur in the case of a simple harmonic E.M.F., and give their results in the form of curves. These are interesting as showing that by choosing a suitable moment for switching on, the maximum value of the current during the first few alternations may considerably exceed its normal value. In commencing the treatment of circuits containing capacity, a short *résumé* of elementary electrostatics is given for the same reason probably as the introductory chapter on magnetism; in it the authors fall into the usual error of stating that two like charges repel one another, instead of adding the word apparently. In Chapter IX. the authors propose the use of the word "impediment" for the quantity, by which the potential difference must be divided to give the current when the circuit contains capacity instead of the word "impedance," as they state this is already used as the name for $\sqrt{R^2 + p^2 L^2}$. It seems very unnecessary to introduce a fresh word as, if we mistake not, the original meaning of "impedance" is the quantity by which the P.D. must be divided to give the current, as distinguished from resistance, which is the quantity by which the square of the current must be multiplied to give the rate of heat dissipation, and this may apply to any circuit, whether containing capacity or not. The last two chapters of Part I. deal with circuits containing distributed capacity, and, as state the authors, "form a separate discussion which may be read alone, and without which the rest of the book is logically complete."

In Part II. only periodic E.M.Fs. are taken, and the same order of treatment is pursued, passing from circuits containing resistance and self-inductance to those containing capacity also. After taking a simple circuit, the series circuit is then considered, next a divided circuit of two branches, and afterwards, one of any number of branches. Graphical representations of the effects of varying the different constants of a circuit or branch are also worked out.

In conclusion, we may say that this book has been written in a most conscientious manner, making it very easy reading; perhaps some parts of it might have, with advantage, been condensed, as there is a good deal of repetition on account of the plan adopted of passing from simpler to more complex cases, while some of the proofs are a little long, but this is a fault that may be well forgiven in consideration of the clearness with which the problems are worked out, and the ease with which any particular one can be turned up. An exceedingly good addition to the book is an appendix containing all the symbols in use throughout it, with explanations of their meanings; there is, moreover, a good index and contents table. We can heartily recommend this book to students commencing the study of alternate currents.

A Practical Guide to the Use of the Edison Phonograph. By JAMES L. ANDEM. Cincinnati, Ohio: C. J. Krehbiel & Co.

This little work gives full information on the management

of a phonograph, much as the catalogues of the manufacturers of type writers give information on the working of their respective machines, with the addition of hints resulting from practice. The use of italics in the instructions for oiling and not oiling, would seem to imply that the brushes of the electromotor have sometimes been lubricated—with the best intentions. The publication of this work indicates that the phonograph either has become or is expected to become in America a more widely used instrument, commercially, than there are at present any signs of here. The work is as well and clearly written as any instructions, without reference to principles, can be.

THE ELECTRIC LIGHTING OF THE TOWN OF BRUSSELS.

THIS heading would lead us to believe that the boulevards, streets and open spaces of the town will shortly be lighted, as in other capitals and many other towns of less importance, by the electric light. This, however, is not yet contemplated.

The gas supply of Brussels is in the hands of the communal administration, and the price at which the gas is sold is regulated so as to cover the cost of lighting the streets; thus the inhabitants employing this mode of lighting pay for the lighting of the streets.

If it were decided to light the streets by electricity, this arrangement would of course be modified. The expense of the new mode of lighting would have to be shared by all the ratepayers, and this would moreover be perfectly legitimate, since all are interested in the town being well lighted and presenting more comfort to its inhabitants and greater attractions to visitors.

Of course, under these new conditions, the consumers of gas would no longer have to pay for the street lighting, and consequently the price of gas would be reduced.

However this advancement may be brought about, it must take place; it is not to be supposed, in short, that the capital should possess a central electric lighting station and not use it for its own requirements. Brussels cannot continue to be less brilliantly lighted than many small towns, and even than certain of its suburbs.

We will now proceed to describe the various parts of the central station and the electric mains supplying the current to consumers.

The site chosen is almost in the centre of the town, between the Rue Saint Catherine, the place of the same name, and the Rue Melsens. It was previously occupied by the Church of Saint Catherine, which had to be pulled down to make room for the new building.

Unlike what may have been expected, from the surrounding property, the soil at this spot was found to be excellent for the foundations.

The work was expeditiously carried out by the London India-Rubber, Gutta-Percha and Telegraph Works Company, under the direction of the engineer, Mr. Stuart A. Russell. This can be seen by this fact: the time demanded for the execution of the contract was ten months, and was to include the construction of the buildings, the mechanical and electrical installations, and the necessary canalisation for the distribution in the town; this period included the two months required for the demolition of the church and the preparation of the ground for the foundation, which caused a delay of some days. The work was, nevertheless, completed in less than eight months.

On arriving at the ground floor, after having passed over a drawbridge, we enter the generator room, which is of sufficient dimensions to contain eight boilers, although two are sufficient for present requirements; they have each 226 square metres of heating surface, and are of the Babcock and Wilcox type, constructed by the firm of Brosehon, at Liège. These steam generators are arranged to burn coke supplied by the gasworks of the town; the fire-grate surface has been, therefore, brought to 5·2 square metres. In the event of coal being used, each boiler is provided with an Orvis smoke consumer. Each pair is furnished with a Green economiser. These apparatus consist of vertical tubes with a heating surface of 192 square metres, through which passes the water for feeding the boilers, and which are heated by the passage of the products of combustion to the chimney.

The water is supplied by two Worthington steam pumps (one in reserve), conveying 2,000 litres an hour. All the water and steam pipes, and also all the escapes and safety valves, are duplicated.

The water used for supplying the generators and for condensation is drawn from the canal basin through two cast-iron pipes, the interior diameter of which is ·45 m. Part of this water, which is drawn up by the principal machines, is sent back into an upper reservoir of 100 cubic metres, being filtered on their way through a Dervaux filter at the rate of 10,000 litres per hour before they pass into the boilers.

The fuel passes over a drawbridge at the entrance of the works, and is carried up to the storeroom by a lift worked by an electric motor. From this storeroom, the capacity of which is 200 tons, the coke is brought down in front of each generator by a large sheet-iron tube, provided with downward cylinders for carrying off the dust.

The dynamo and engine room, which is 36 metres long, 15·5 m. wide, and 8·5 high, is somewhat higher than the boiler house. It contains at present two compound machines on the Sulzer system, constructed by the firm of Carels. These are condensing engines, but can, if necessary, exhaust into the air. The small cylinders are 675 millimetres in diameter, the larger ones 1·01, the average speed of the pistons is 1,200, and the number of revolutions per minute is from 62 to 75. Between the cylinders, which are far apart, are the heaters. An axle, common to two cylinders, one large, the other small, bears two fly-wheels 6 metres in diameter; each fly-wheel bears nine grooves for ropes 40 millimetres in diameter, and weighs 20 tons. This room could hold two more similar machines, and could easily be extended so as to enable two other supplementary machines to be installed. Under the engine room is a solid foundation two metres thick, insulated from the walls. No shaking is perceptible while the engines are at work.

A travelling crane of 15 tons enables any of the working parts of the dynamo to be quickly removed, and replaced by others which are always in readiness.

Behind each engine are two dynamos of four poles and a drum ring, constructed by the Société Electrique et Hydraulique, of Charleroi, from the drawings of the India-Rubber Company; each is capable of an output of 143 kilowatts at a speed of 300 to 360 revolutions.

They are attached in pairs to each of the two engines, and are each worked by the nine cables of the fly-wheels. They give, when working normally, 1,100 ampères at 130 volts. For charging accumulators they each give at 360 revolutions 860 ampères at 180 volts.

Their weight is 17 tons, the base and the inductors weighing 9,700 kilogrammes and the axle and movable armature 3,100 kilogrammes.

The base is of cast steel, and is made in two pieces united by bolts. The inductors are cast in iron along with the base. The inductive bobbins, of rectangular section, are adjusted to these inductors by two extensions of soft iron screwed into their extremities. The bobbins consist of a sheet-iron core provided with strong wooden fins. They are wound with electrolytic copper wire, 41/10, insulated by a triple covering of cotton coated with shellac.

The armature, in the form of a drum, consists of a core held on the axle by means of two cross bars. The core consists of discs of soft sheet iron joined together and coated with an insulating varnish.

The coils of the armature are bars of rectangular section composed of copper wires twisted and cabled together, and then laminated.

The commutator consists of sheets of red copper, separated by plates of mica.

The brush-holders are of bronze, and are four in number. They each hold four brushes; these are of red copper. The displacement of the brush-holders is effected by means of a runner of cast-iron, moved by an endless screw with a hand fly-wheel.

Each dynamo is mounted on a framework actuated by an endless screw working a gearing.

The battery of accumulators of the Julien type, constructed by the Electrical Company, comprises 140 cells, the plates, including the contacts, weighing 325 kilogrammes; it is placed in a large room on the floor above the engine room. Its total weight is 80 tons; arrangements are made for the installation of a second similar battery over the first. The cases are of antimoniated lead, resting on oaken framework, supported by porcelain insulators. The 140 cells form two batteries of 70 each; 26 cells of each battery are connected by insulated cables to the wires of the distribution board, so as to enable the number in the charging or discharging circuit to vary from 14 to 70.

Each cell can give a discharge of 350 ampères in 10 hours. In exceptional cases during the time required necessary for starting a second engine in case of accident to the first, the battery could give a discharge of 1,400 ampères. The distribution board is placed in the centre of one of the long sides of the engine room on an iron balcony, at a height of 3·8 metres. On this are disposed the apparatus and connections necessary for the service of the dynamos and accumulators over a three-wire distribution. It is arranged for six engines, each of which would work two dynamos at 130 volts, or a single one at 260 volts, starting from the third unit.

We shall shortly give a special complete description of this distribution board, and also of laboratories for electrical measurements and meter tests.

The mains are laid on the three-wire system, with a tension of 110 volts at each point of the centres of distribution. This tension is reduced to 100 volts for the Quartier and the Avenue Louise. A loss of 30 volts is thus allowed for the feeders directed to those distant districts, which enables the copper section of the conductors to be greatly reduced. The demand for electricity in these districts is not expected to be of much importance at first; but when it is sufficient to justify the establishment of a secondary station, these feeders of small section will be removed and used as distribution cables.

The cables are formed of copper of at least 100 per cent. of the conductivity of copper of the Matthieson standard. The wires are tinned, then covered with a layer of pure India-rubber, a layer of vulcanised India-rubber, a layer of ribbon coated with India-rubber, and a strand of impregnated hemp. The insulation resistance is 2,500 megohms per kilometre.

The cables are laid in cast-iron pipes, connected by India-rubber joints. The distributing boxes are placed at the corners of the streets, or at distances not exceeding 80 metres. The whole canalisation is laid under the pavements; the lids of the distributing boxes and of the cases of the joints are of cast-iron, cemented with asphalte.

The number of lamps subscribed for up to the present is 3,773 16-candle lamps, or their equivalent, not including the lighting of the Theatre de la Monnaie and the Hotel de Ville. Nine centres of distribution have been established at the following points:—The Exchange, the Hotel de Ville, the Theatre de la Monnaie, the Alhambra, the Boulevard du Nord, the Rue du Marais, the Rue Sainte-Gudule, the Park, and the Place Royale. These centres are connected by distribution cables, forming a network through all the principal streets. We will conclude by saying that the electrical meters in use in the private houses are of the Brillié and Thomson-Houston types.—*Le Mouvement Economique.*

THE PRIMARY ACTION OF THE GALVANIC CURRENT.

By J. MOUNT BLEYER, M.D., and M. MILTON WEILL, M.D.

(*Continued from page* 542.)

Preliminary Tests.

For a period of 72 hours before entering upon the examinations, we hung in various portions of our laboratory slips of specially prepared paper, saturated with a solution of the iodide of starch, and others moistened with tinct. guiac. These, as we all know, are acknowledged tests upon ozone. We kept the papers under careful observation, examining them in strong light at intervals of an hour, and as there was no evidence of a reaction at the end of the allotted time we were justified in concluding that the atmosphere of the laboratory was free from ozone and the other gases which act upon starch and guiac. Next we directed our attention to nitrous compounds in the air, for the reason that they—if they exist in the slightest appreciable quantity—give us a reaction very much like that of ozone, and their presence must be excluded in order to give any sensitive test for ozone practical chemical value.

The test we applied for nitrous compounds is an extremely useful one, unusually sensitive, and we give its chemistry for the benefit of those who may desire to repeat our experiments. It is named Gries's test, after its discoverer. He observed that in sulphanilic acid and naphthylamine we have a reagent which acts on nitrous acid, but not on H_2O_2 or O_3. This discovery Gries made while engaged in studying the action of diazo-benzene-sulphonic acid on naphthylamine.

He obtained his diazo-benzene-sulphonic acid by treating sulphanilic acid with nitrous acid, and calls attention to the extreme delicacy of the reaction, minute traces of nitrous acid sufficing to produce a dark red colour in the presence of dilute sulphuric acid. The coloured substance formed is an amido-azo derivative of the formula

$$* C_6 H_4 (So_3 H) N = N C_{10} H_6 NH_2$$

called azo-amido-naphthalene-benzene-sulphonic acid.

Prof. Slosvay,† of the Polytechnic School at Buda-Pesth, increases the sensitiveness of the reaction by substituting acetic acid for sulphuric acid, and he can detect with it nitrous acid in aqueous solution in a dilution of one part nitrous acid to one thousand million parts of water.

The formula of the test is:

$$C_6 H_4 NH_2 (So_3 H) + C_{10} H_7 NH_2 + No_2 = C_6 H_4 (So_3 H) N = NC_{10} H_6 NH_2$$ sulphanilic acid and naphthylamine.

We availed ourselves of Slosvay's modification of Gries's formula.

A tank of a capacity of 50 gallons at a pressure of 30 pounds was filled with air from the laboratory. The air was sent through an air meter which registered one litre per minute, and from this into a test tube containing distilled water, through which it was allowed to bubble for 10 minutes and then tested.

There was no immediate reaction, and only after half an hour's standing did we observe a tinge of colour; so faint, however, as to be almost imperceptible in ordinary light. In order to see it, we were obliged to back the test tube with pure white filter paper and hold it in the sunlight.

In view of the delicacy of Slosvay's reaction, it was fair to assume that the quantity of nitrous acid in the air was so infinitesimally small that for practical purposes it could have no effect in interfering with the subsequent tests for ozone.

10 litres of oxygen were treated in the same manner. The oxygen was first subjected to two washings in distilled water without giving any reaction to the nitrous acid test. The remaining 40 gallons which were afterwards liberated in the laboratory were washed in caustic soda and dried with sulphuric acid (C.P.) and bubbled through distilled water. There was no reaction with Gries's test, thus showing that the gas was absolutely pure and free from admixture with nitrous and other gases.

This concluded the preliminary testing. The object of the careful analysing of the air of the laboratory as you may already divine, was to devise means of testing for ozone in the open, and to avoid the less satisfactory method used by Schmitt, who treated his ozone in a balloon from which the oxygen had been removed as nearly as possible to do so, by means of carbon dioxide, or handling it in a similar glass receiver, from which all air had been exhausted, which was the manner in which Kühne conducted his experiments.

For several days work was suspended, and resumed again Monday, August 21st. On that morning we were treated to a genuine surprise, that caused us to ponder for a while. Dr. J. C. Dittrich, who, perhaps, ranks first among the authorities on ozone in this country, and who kindly assisted us in the chemical portion of our work, prepared several specially sensitive test papers, which, on being moistened with distilled water, at once gave a reaction. The air of the laboratory was evidently charged with ozone, and we were at a loss to account for its presence. Speculation was soon set at rest when we recalled the violent thunderstorms of the Sunday and Saturday before.

The ozone was the result of the intense static discharges of those days, and the amount that had been generated by the great Pluvius certainly was enormous and beyond measure. For that day and the three succeeding ones, work had to be deferred, with all the preliminary testing for naught.

On the following Thursday, on resuming operation, no ozone or nitrous acid was detected in the laboratory. The preliminary tests on being repeated gave results as already stated.

Testing for Ozone in the Blood.

A rabbit that had been well fed for a week was the subject of investigation—it was a big animal, in fine spirit, and weighed four pounds three ounces. It was brought into the laboratory, and both carotids cut through and the blood collected in a sterilised glass receiver. In all, 60 grammes were extracted and defibrinated with sterilised glass rods. The operation requires nine minutes, and the fresh serum was subjected to test.

The serum was diluted with distilled water, in the proportion of one part of serum to four of water.

With the iodide of starch an immediate reaction was observed in the open air, and the same reaction, faint at first, but gradually deepening in blue colour, showed under a glass bell.

Testing with guiac tincture of the officinal strength, which we

* *Ber. d. Chem. Gesell.*, 12, 426, 15, 2,191.

† *Bulletin de la Societé Chimique de Paris*, Sept. and Nov., 1889.

reduced by adding an equal volume of absolute alcohol, responded more quickly to reaction of ozone. The blue ring around each drop of blood was marked and sharply defined. The same reaction continued when the test was made under the bell glass, and gradually approached its maximum of intensity at the end of half an hour, when, to all appearances the ozone became completely exhausted.

The fibrinous clot, with the entrapped corpuscles, was likewise tested, and gave a far more distinct and marked reaction than the serum.

It was evident at a glance that the corpuscles contained a far larger amount of ozone than the plasma.

The remainder of the defibrinated blood, about 40 grammes, which had been kept in a well-covered jar, was next subjected to electrification for five minutes.

A galvanic current of 10 volts and 15 milliampères was sent through the fluid. The electrodes used being strips of platinum an inch long and $\frac{3}{8}$ths inch wide.

In six seconds the meter dropped to eight mil. ampères, and the registration which was recorded at the end of each minute read as follows:—

1	minute	7	mil. ampères.
2	„	5	„
3	„	4·5	„
4	„	3·75	„
5	„	3 +	„

Testing with iodide of starch and guiac tincture showed the unmistakably increase of ozone. The rings around the drops of blood were of deeply blue hue, and the reaction continued on with much greater rapidity than was the case of the unelectrified blood. As quantitative test was out of question, Dr. Dittrich and my colleague made an approximation of the intensity of the action by comparing the rapidly deepening ring of blue with the chromatic scale, given by Dr. Fox in his exhaustive work on ozone. They carefully noted the change of colour as it progressed, availing themselves of the most advantageous light facilities, and agreed upon the estimate that the amount of ozone adequate to such reaction must be in the neighbourhood of, at the lowest calculation, at least two and one-half times greater than the amount indicated by the reaction in the case of the unelectrified blood. The clot deposited around the electrode at the positive pole gave a more animated reaction, the ring of blue almost approaching indigo, showing a most marked increase over the former reaction.

Standing by itself this test of the blood outside of the body signifies but little, for it is the blood that circulates through the living organism unimpeded with which we have to deal and in which physiological conditions alone can be of any value in the study of the action of the galvanic current. Yet withal, when taken in connection with the tests that were afterwards made, the observations form an important link in the chain of evidence that it is animal electricity which is the polariser of the atoms of neutral oxygen, both in the plasma and in the hæmoglobin.

Under normal conditions the transformation of O_3 into O_2 is slow and gradual, and the polarisation of the neutral oxygen is proportionate to the polarising force of the existing animal electricity.

Undoubtedly Schmitt, Houzeau, Meisner, Kühne and others were right in their assumptions, but it seems to us that they did not probe deep enough for a solution of the possible origin of this transformation of neutral oxygen into ozone within the human economy. It was due to the polarisation of the atoms of the neutral oxygen, but how did it come about?

We have assumed in starting out upon the experiments the results of which form the title of the paper which we have the honour of presenting to your consideration, together with the more exact details which we hope to announce at some future day, step by step, with the view of adding some light to the question, that this generation of ozone admits of a satisfactory scientific explanation.

During the years that my colleague and myself have devoted to the study of ozone within the body, we have always regarded it with awe and veneration. We have woven theory after theory only to find that the strands broke precisely within the limits of the reasoning of the great observers to whom we owe all we know of ozone, and that to us as physiologists, is indeed little.

That ozone can be found in the blood nourished by gases that contain no ozone is a fact beyond dispute, yet the problem of its generation is a problem that at first sight offers no easy solution.

In looking over the field of possible sources to explain this source of the formation of ozone it fastened itself upon us that one great factor that might afford an explanation, had been overlooked. It was animal electricity, and we have tried to explain its function. There seems to be but one deduction to draw from the most careful observation and that is, that it is animal electricity upon which not only the polarisation of the atoms of oxygen but all molecular polarisation and chemical action in the body depends.

We believe that the transformation of oxygen into ozone within the body is brought about by this very animal electricity, which polarises the neutral oxygen to such a degree that a portion of the atoms rearrange themselves, attract and repel each other under this polarising force until we get the ozone which we detect upon analysis. The function of the ozone is apparent to all of us. It gives the oxygen increased power to form combinations with the tissue elements and promotes oxidation.

This polarisation of the oxygen seems to take place just as the gas touches the tissues where the conditions are favourable to such an action and where it closes circuit with electricity in the human frame. The unaffected molecules of oxygen under the vigorous spurring of this ozone become vitalised as it were and at once begin the search for their affinities in the tissues and enter into combination with them.

The proof of this reasoning seems to us to be apparent from the fact that we have been able to appreciably increase the amount of ozone in the blood by passing very weak currents of galvanic electricity through the body, and it is the underlying theory upon which we based our experiments and which we hope to make clear to you.

Before dismissing this portion of our paper and passing over to an account of our experiments upon the blood of the living animal electrified by a current of galvanic electricity, permit us to advance another theory which we regard as justifiable from our findings, and we do so only in the hope that it will give rise to careful discussion, for it is at variance with some of our pet physiological theories; it is

That oxygen in the blood stimulated by the polarising power of animal electricity, and more so under the stimulus of the galvanic current enters into combination with the Hæmoglobin of the corpuscles with a partial transformation into ozone, and that in loosing its combining bonds it undergoes a further partial transformation into ozone.

EXPERIMENTS ON THE ELECTRIFIED ANIMAL.

This brings us to a record of the experiment upon the living animal with the galvanic current.

The animal chosen was also a rabbit, which was prepared by being fed on fresh vegetables for several days. It was in prime condition and was allowed to run at large until required for use. The batteries, two of the ordinary 24-cell medical machines of the Edison-Lelande pattern were used. The batteries were carefully tested cell by cell and the current measured with both volt and mil. ampèremeter. A coil of a resistance of 400 ohms which had been placed in the circuit was removed after the measurement had been taken and we decided upon a current of a strength not to exceed 40 mil. ampères.

Two cuts about half an inch apart were made into the skin of the animal and into these and for a distance into the body of the muscle, the platinum electrodes used in the previous experiment were inserted and a current of 20 volts turned on. The meter showed 44 mil. ampères. This dropped quickly down to 41 mil. ampères. The reading of the meter during the 5 minutes that the current flowed was as follows:

1	minute	40·5	mil. ampères.
2	„	38·	„
3	„	37·+	„
4	„	35·8	„
5	„	35·—	„

At the end of five minutes both carotids were cut through and 35 grammes of blood were drawn into a sterilised glass vessel and defibrinated as before with sterilised glass rods.

It was observed that the blood was of a brighter scarlet hue than that which flowed from the arteries of the unelectrified animal.

Exposure to the air while the process of defibrination was going on did not affect the bright tint. Defibrination, too, was not so easily effected and the fibrin slowly gathered around the rods.

Seven minutes after the blood was shed a gramme of the fresh serum was diluted with two grammes of distilled water and subjected to test with both guiac and starch iodide. The reaction in both instances was almost immediate, a trifle more active with the guiac. The ring of blue around the drops of blood was more pronounced and much deeper and kept on deepening both in the open air and under the bell jar as had been done with the blood from the first animal killed. At the end of twenty minutes the test papers, those saturated with guiac and starch iodide, three of each variety being exposed to the air and a similar number under bell jars, indicated the termination of the action and they were taken out and carefully compared with the test records of the first experiment which had been preserved in air-tight tubes. The blue ring was, even upon the most superficial examination, found to be several shades deeper and the ring of reaction was more spreading, in some of the drops, almost half an inch wide and distinctly visible to the line of demarcation of chemical action. The fibrin also gave like results. A far larger amount of iodine had been set free in these tests than in the case of the first analysis. The quantity of ozone to give such reaction according to a most conservative calculation of both Dr. Dittrich and my colleague was estimated to be certainly three times greater than that which gave the reaction from the normal blood.

The increase in the amount of ozone was astonishing and far beyond our expectations. We had anticipated some difficulty in determining the increase if it proved to be trifling, but here we were met by a quantity far in excess of what we had hoped to find in the event of the most successful termination of our searching.

The action of the current on the oxygen in both plasma and corpuscle enmeshed fibrin was evident in the transformation of a portion of it into the more vital form of O_3. That the current had accomplished this transformation (astonishing as it proved to be), was readily to be explained, but not so with the ozone in the normal blood. There was but one explanation for this, the polarising action of the animal electricity.

(To be concluded.)

AUSTRALIAN ELECTRICAL NEWS.

[FROM OUR OWN CORRESPONDENT.]

ELECTRICAL work in Australasia has not been over brisk during the last few months, but a few important installations have been enlarged and some new ones have been put in. The private lighting at Redfern has been steadily going ahead, and the number of houses and shops taking the light steadily increasing. There are now some

thirty odd buildings to which current is being supplied, the meter system having been recently introduced; of these, five are private houses, three hotels, and the remainder shops. Another of the eyes has been picked out of Sydney, from the Municipal point of view, by the erection by Mr. A. H. McArthur of a central station to light a block of buildings known as the Strand Arcade, the wiring of which was installed by the Williamson Electrical and Engineering Company when the place was built. The lighting from this central station, erected under the supervision of Mr. G. D. Hamilton, of the Electrical Material Company, is not, of course, confined to the Arcade, but is already extended to several business premises in King Street, George Street, and Pitt Street, and many more applications are in hand.

The Brush Electrical Engineering Company, which always gets a fair share of the business going, has been supplying a good deal of plant lately for extension of plant in various parts of the colonies, including a 25-unit Mordey alternator to the Broken Hill Proprietary mine; a 200-light Victoria machine for the Mt. Zaehan mine, Tasmania, for lighting the works and underground workings; a new 55 arc light dynamo to replace a Western Electric at Mt. Morgan mine, Queensland, which I hear is for the purpose of extending the arc lighting into the workings. This company has also put in vulca insulated conduits over the whole of the new buildings being erected for the Equitable Insurance Company, of New York, a fine large stone building which will require a plant of at least 800 lights. The City Bank of Sydney, which is nearing completion, another fine building, is being installed throughout by this firm. It is to be a 400-light plant supplied by a Victoria dynamo run by a high-speed Otto gas engine. The wiring arrangements are very good, no branch wires carrying more than 10 lights, each floor being cut up into several circuits all coming back to a very neat fuse-board, the main cables running direct without joints or branches from the main switchboard to the fuse-boards on each floor. The new type of Callender cable is being used throughout. A set of 23 L. E.P.S. accumulators will be used in this plant. The main distributing switchboard, which is now in place, is very handsome, having a fine white marble base.

The Rockhampton central station, recently completed, is an undoubted success, and the demand for current increasing at a rapid rate. The town is divided into three areas, low tension, high tension, and extra high tension. The low tension area is already taken up, and the Brush Company have just supplied a 25-unit Mordey alternator for the high tension area, and this is already loaded to nearly its full capacity; a number of alternating arc lamps have also been supplied by the Brush Company for this area. In the central station, Root water tube boilers are used, supplying steam to a 100 H.P. Davey-Paxman engine, which runs a 500-light Kingdon dynamo, made by Chamberlain and Hookham. Vulcanised rubber and vulcanised bitumen cables are used, the feeders being run in wooden troughs and run in solid with bitumen, the mains being run in iron pipes.

The Electric Club has just successfully concluded its second year; several excellent papers have been read, productive of good results. The pumping plant for the Co-operative Colliery has arrived, and the installation will shortly be completed by the Crompton Company. This was a direct result of Mr. Brain's paper on "Electricity as applied to mining." A further result of a paper read before the club, in this case, Mr. Dymond's paper on "Fire Insurance Rules," has been the appointment of a permanent electrical inspector, Mr. Arthur C. F. Webb, M.I.E.E., late of the Telegraph Department, having been appointed to the post. Owing to a somewhat similar case in Queensland, *i.e.*, the fire insurance inspector being connected with a contracting firm, Mr. Webb has been requested to also undertake the Queensland inspectorship. A new set of rules is to be drawn up for New South Wales, which will probably be adopted in Queensland, a step in the direction of universal rules throughout the Australasian colonies, the rules of the various colonies at present being, as Mr. Dymond pointed out in his paper, widely different in many respects.

LEGAL.

THE MEDICAL BATTERY COMPANY.—COMPULSORY LIQUIDATION.

IN the Chancery Division of the High Court, on Wednesday, the petition of Mr. T. B. Browne for the compulsory winding-up of the Medical Battery Company again came before Mr. Justice Vaughan Williams.

Mr. C. E. JENKINS appeared for the petitioner, a trade creditor, and suggested that there was no reason why the voluntary liquidation should not be continued under the supervision of the Court, and that Mr. Whinney should be appointed liquidator along with Mr. Davis, who had been made receiver and voluntary liquidator in the debenture-holders' action. Then, if Mr. Davis retired, as he had a perfect right to do, Mr. Whinney would remain voluntary liquidator. Mr. Davis had expressed his willingness to retire.

Mr. HENDERSON, counsel for the Medical Battery Company, said he would undertake that Mr. Davis should retire.

Mr. JENKINS urged the Court to the conclusion that this was not a case for a compulsory order.

Mr. JUSTICE WILLIAMS: If the shareholders wish for a voluntary liquidation, I ought to allow them to have their wish carried out, unless somebody proves to me that the rights of the creditors will be prejudiced.

Mr. HENDERSON read an affidavit by the present voluntary liquidator, Mr. Davis, in which he said that more than one-half of the debentures were, he believed, held by persons perfectly independent of Mr. Harness. It was the opinion of Mr. Davis that if a compulsory winding-up was ordered, neither the unsecured creditors nor the shareholders would receive anything.

Mr. JUSTICE WILLIAMS: Is there any reasonable prospect that by carrying on this business the unsecured creditors or shareholders will be at all likely to get any more money than they would do if this business was wound up at once?

Mr. HENDERSON said that matter had been dealt with in an affidavit of Mr. Davis. In consequence of the recent attacks on the company, Mr. Harness thought it right to institute criminal proceedings against a London paper, and the directors voted £250 to Mr. Harness and his solicitor for these proceedings. Proceedings had been commenced, but not criminal proceedings, and Mr. Davis said if he continued liquidator, he ought to have advice as to whether steps should not be taken to recover the £250 from Mr. Harness and the other directors who were present when it was voted to Mr. Harness. The business which had been carried on by the company had resulted in very large takings, almost entirely cash, and the annual total income was put at £51,531.

Mr. JUSTICE WILLIAMS: I should like Mr. Davis to give me some facts which lead him to the conclusions that the goodwill of the business is of considerable value.

Mr. HENDERSON said that apart from the large cash takings, there were the stock in trade, valuable appliances, &c. The company was at the present moment under a cloud, but the cloud might be removed. Mr. Henderson submitted that no case had been made out for a compulsory winding-up order.

As representing several creditors, Mr. EDE pressed for a compulsory order. The voluntary winding-up which the Court was asked to father was a liquidation confessedly with the object of reconstruction. The creditors of the company had been hampered throughout by the action of the petitioner, and the fact of there being a receiver for the debenture holders. Very grave charges had been brought against this company, which required investigation.

Mr. JUSTICE WILLIAMS: I do not know what those charges are.

Mr. EDE said the charges were that the business was a fraud from beginning to end, and that the company was a swindle.

Mr. Bramwell Davis and Mr. McNaughten appeared for various creditors in support of a compulsory order.

Mr. HENDERSON pointed out the charges against this company were being investigated at the police court, and therefore there was no necessity for an investigation by the Official Receiver.

Mr. JUSTICE WILLIAMS, in delivering judgment, said the matter had occupied a great deal of time, because it was his duty to take care that he did not allow the petition to be determined by any of the topics of prejudice which had been so freely put forward. He should not allow attacks upon Mr. Harness, or the police court proceedings to influence his decision. At the time the petition was presented there had been no resolution for voluntary liquidation. All that had occurred was that a debenture holder's action had been commenced, and Mr. Davis appointed receiver. Now would the rights of creditors be prejudiced by a voluntary winding up? It was quite clear that the control of this company was chiefly with Mr. Harness, and that Mr. Davis was the nominee of the debenture holders. The number of independent shareholders was small, and under the circumstances, he was of opinion that it would be prejudicial to the creditors generally that the liquidation should continue under the control of the shareholders, especially as the receiver in the debenture action was the nominee of the shareholders. He should make a compulsory order, and wished it to be understood that he was in no way influenced by the suggestions that he should make this order for the purpose of investigating the charges against the managing director.

Mr. HENDERSON asked for a stay of execution of the order, with the view to appeal against it.

His LORDSHIP said the stay would be useless.

THE ELIESON ACCUMULATOR (BRITISH PATENT) SYNDICATE, LIMITED, *v.* THE EARL OF GALLOWAY.

IN the Queen's Bench Division of the High Court, on Wednesday, Mr. Justice Kennedy gave judgments in the case of the Elieson Accumulator (British Patent) Syndicate, Limited *v.* the Earl of Galloway. The action was brought to recover a sum of money alleged to be due in respect of 2,000 shares allotted to the defendant in the company. The defendant, in addition to formal defences, denied that the application for shares, which was made by a Mr. Watson Smith on his behalf, was authorised; that if any authority was given it was countermanded before the allotment, and he counterclaimed to have his name removed from the register of shareholders, and for the return of £100 which he had paid to Smith as a deposit on the shares. His Lordship said that in 1892 Mr. Watson Smith, who was an accountant in the City, formed the idea of promoting a company for the purpose of making available for commercial purposes an English patent held by Mr. Elieson, an inventor, in regard to the use of an accumulator for tram cars and other things. Mr. Smith got into communication with Lord Galloway, who seemed to have been somewhat easily drawn, and in the result his Lordship, on certain conditions, consented to become a shareholder in the proposed company, forwarding to Mr. Smith £100 as a deposit on the shares. Mr. Smith went on pushing the concern, but it was obvious that the only possible reason or justification for its existence was, that he had in some way the power to call upon Mr. Elieson to make a contract by which the company would become the owners of the patent. An agreement was drawn up by which Mr. Elieson agreed to sell his English patent for £6,000, but that agreement was never confirmed, and under the circumstances there was nothing for the company to do. A prospectus was, however, drawn up, and the company was registered. On October 14th there was a meeting of the company, Mr. Watson

Smith acting as chairman, and it was alleged that at that meeting the allotment of shares was made to Lord Galloway. The evidence as to that allotment was not satisfactory, but assuming that an allotment did in fact take place, it was curious that at a subsequent meeting at which Mr. Elieson, Mr. Watson Smith, Lord Galloway, and Lord Sackville Cecil were present, no mention was made by Mr. Smith of that allotment. That was an extraordinary fact, for nothing would have been more natural or easy. Good faith and honour required that statement to be made. *Primâ facie* Lord Galloway was a shareholder, but the question then arose whether the conditions on which his Lordship consented to become a shareholder had been carried out. He thought those conditions had not been carried out, and that any authority that had been given was revoked. On these grounds he came to the conclusion that the defendant was entitled to succeed in the action, and judgment would be given for him with costs. He was also entitled to have his name expunged from the register of shareholders, but he could not recover the £100. There was no evidence that that money had ever got into the possession of the company, and they were not accountable to Lord Galloway for it. On that part of the counter claim judgment would be for the plaintiffs.

THE DINNER OF THE ELECTRICAL ENGINEERS.

ONE of the most successful dinners of the Institution was that held on Wednesday night. Mr. Preece presided, and there were present, among others, the following gentlemen:—Mr. Mundella, President of the Board of Trade; Mr. A. Morley, Postmaster-General; Sir F. Bramwell, Prof. G. Carey Foster, Mr. Jacob Brett, Mr. Latimer Clark, Mr. E. Windsor Richards, president of the Iron and Steel Institute; Prof. Rücker, president of the Physical Society; Sir R. Rawlinson and Mr. J. Wolfe Barry, vice-presidents of the Institute of Civil Engineers; Mr. Algernon Turner, C.B.; Mr. W. H. M. Christie, Astronomer Royal; Mr. H. Joyce, C.B., Secretary, General Post Office; Sir T. Blomefield, Board of Trade; Mr. Ward, local honorary secretary for U.S.A.; Mr. Lamb, C.M.G., Mr. Butcher, M.P., and Mr. Webb, secretary.

The PRESIDENT, after dinner, and after the toast of the Queen had been honoured, briefly proposed "The Learned Societies."

Sir J. CRICHTON BROWNE, responding, said the learned societies were all standing tip-toe, eager to see what electrical engineers were going to do next. They were full of gratitude and admiration for the splendid achievements of electrical engineers in recent years, and they had a lively sense of favours to come. They had festooned our homes with beautified glowworms; they had stretched our ears, not in any asinine sense, so that they extended all over the town, and even as far as Paris; they had kept us in hourly and sympathetic vibration with everything that was going on in the uttermost quarters of the world; they whirled us about; they elevated them and depressed them; they welded our metals like the gnomes; they performed chemical trasmutations like the alchemists; and they even treated us when we were ill, like the Royal College of Physicians. (Laughter.) They had vastly increased the comforts and convenience of modern life; they had added enormously to the means of human intercourse; they had afforded invaluable assistance to the students and investigators in every department of science. To find a parallel to their splendid achievements of recent years, and to the expectations they had created, it would be necessary to go back to the 16th century, when Columbus and his followers, by their discoveries in the new world, created great hope and expectation; and he was certain that when the history of Queen Victoria's reign came to be written there would be no more brilliant chapter in that history than the one which recorded the exploits of electrical science.

Prof. RUCKER also responded.

Prof. W. E. AYRTON, past-president, gave the toast of "The Engineering Societies," and Sir F. BRAMWELL responded.

Mr. A. MORLEY, acknowledging the toast of "The Guests," proposed by Mr. LATIMER CLARK, expressed the opinion that no commercial undertaking, certainly no department of the State, was more dependent upon or interested in the successful development of electricity than that branch of the service with which the president was connected, and over which he himself had the honour to preside. It was common knowledge that the success of our telegraph and telephone systems was dependent upon the successful utilisation of electrical currents, and he did not think he claimed too much when he said, with regard to the first of those services, that we had at least taken the foremost place among the nations of the world, even if we were not entitled to claim that we had surpassed all other nations on both sides of the Atlantic, and that we had provided a service which was superior to that of any other country. A series of almost unprecedented storms had lately been experienced, and he was glad to be able to report that the telegraphic service of the country had almost without exception been uninterrupted by those serious disturbances. It was not so with some of our continental competitors, and two days ago, speaking telegraphically, we had once again absorbed Calais within the Empire of Great Britain, because all telegraphic communication with Calais was for a time entirely suspended, except by the wire which connected Calais with London. He did not know that he could say so much with regard to our telephone system, but he had very little doubt that the time was not far distant when that system would be equal, if not superior, to the telephone of any other country. The right hon. gentleman referred to the benefits which had resulted from the introduction of the electric light in the General Post Office, and mentioned that trials were now being made there with an electrical machine which defaced stamps at the rate of 560 or 580 a minute, as compared with 150 a minute defaced by the old method.

Mr. MUNDELLA proposed the toast of the evening, "The Institution of Electrical Engineers." He took occasion to mention that the excellent work done by the Electrical Standards Committee had been approved generally by electricians throughout the world. France, Germany, and the United States were prepared to adopt them, and he was so much encouraged by all he heard of the prospects of an international arrangement that it would shortly be his duty to submit an Order in Council to her Majesty adopting the electrical standards as the standards for this country, and he hoped for the civilised world. They were making progress in this country with respect to electric lighting, for whereas when he addressed them last year there were only 26 local authorities which had obtained orders approved by the Board of Trade, now there were 46 local authorities in that position and 62 companies. He acknowledged the indebtedness of the Board of Trade to the institution, and cordially desired the development and extension of its operations. There was room for a good deal to be done in England, for example, in the way of extending electric railways.

The PRESIDENT, in reply, said it had been his lucky fortune to have been instrumental in introducing the institution to nearly all the wonderful developments of electricity that had so singularly distinguished this last half of this Victorian age, and this was greatly owing to his frequent visits to that energising country, the United States of America. In only one branch of electrical industry could we compare favourably with our American cousins, and that was in telegraphy. We were certainly ahead of them in that field, but in every other branch, especially telephony, we were behind in material progress, and we had very much indeed to learn from their rapid advances and their practical ways. But our advance, though slow, was sure, and he was not quite sure that we should not win in the long run. He touched upon the growth of electric railways and the electric light, and claimed that the electric light was the poor man's light. The trouble experienced was not that it was too dear, but that it was too cheap. The growth of the Institution of Electrical Engineers was shown by the fact that the total number of members of all classes on January 1st, 1873, was 352, while at the present time it was 2,260, and the average number of members elected annually during the last six years had been 225. The institute dealt with the present, and its object was to collect facts, to circulate truth, to cement friendship, and to provide for its scattered brotherhood a local habitation and a name.

THE CITY AND SOUTH LONDON RAILWAY.

WITHIN the past few weeks letters have appeared in some of the evening and other newspapers, in which the directors of the City and South London Railway are charged with working their lines upon the "sweating" system. Seeing these letters, and doubting the accuracy of the statements therein made, we called upon Mr. Thomas C. Jenkin, the general manager of the railway, and with his kind assistance have carefully investigated the whole matter, with the result of discovering that, compared with other railways in the United Kingdom, the City and South London employés are apparently more liberally paid, and are engaged at their work less hours per day, than are the men on other lines.

The locomotive cleaners and drivers are the chief classes on whose behalf the writers in question take up the cudgels; but from data in our possession, which it is needless to set forth in detail here, we understand that for the duties performed and the capabilities of the men who carry them out, the wages are sufficient, as, contrary to what the correspondent of the papers says, the men who receive the lowest wages are young unmarried men. Furthermore, the work of cleaning the electric locomotives is merely ordinary labour for which the company consider youths of from 16 to 17 years of age would be just as competent as the older married workmen.

The drivers' assistants, to whom reference is also made, have very little work to do, as unlike steam locomotives, there are on the City and South London line no coaling or similar duties for the assistant to accomplish. In fact, like Othello's, the stoker's occupation is gone. Therefore in this case, as in that of the cleaners, youths would be equally competent for the work as the older hands. There are a number of these assistants who will eventually, if deserving, be promoted to the post of driver, and the drivers, we know for a fact, are by no means badly remunerated. It is obvious that unless employés can remain for a period as assistants at assistants' wages they can hardly hope for promotion.

The lack of meal times has been complained of, but fault might be found with many railway companies on this point, if anyone is dissatisfied with the men having to take their meals whilst stationed on their locomotives. Suffice to say that the drivers' are cared for in this respect quite as much as on other railways.

As a matter of fact, there have been no complaints whatever put forward by the men, and the letters would appear to be mere attempts to stir up strife.

One writer says there is "bullying" by the inspectors and signalmen. But it is evident that with a quick service such as is run through the so-called "pipe" there must be no unnecessary delay, to the inconvenience of passengers; and promptness in getting passengers into their places, which some people may mistake for "bullying," is therefore very necessary on the part of the officials.

We purposely do not deal with some other paltry complaints, as we cannot spare the space, but from the statements we have made, it will be easily seen that the letters were penned by some person or persons knowing very little indeed regarding the working of the line, and we have pleasure in inserting this contradiction. It cannot rightly be expected that a young company, which has only just begun to feel its way financially, can pose as a philanthropic concern, as a few hundred pounds additional expenditure on wages would make a great difference to the profits on an enterprise paying less than 1 per cent. dividend on its ordinary stock.

Apart from the subject of the employés wages, our representative, in the course of his interview with Mr. Jenkin questioned that gentleman as to the reason for the decreases that have taken place lately in the traffic receipts as compared with the corresponding periods of previous years. Mr. Jenkin stated that the only conceivable cause for this is, that there has been no football played at Kennington Oval this season, and that the protracted period of dry hot weather has influenced passengers to prefer omnibus travelling to that of an underground tunnel. We may incidentally mention that very shortly the company will be running more trains than at present, and for the greater convenience of passengers, they recently duplicated the lights in one of the trains as an experiment, with the result that the board have now decided to effect this improvement in all of their trains, at considerable expense. With this improvement, and the absence of breakdowns, there will presently be very little cause for complaint.

It will be no surprise to us, when the prevailing financial depression has cleared off, to hear that the directors are appealing to the public for capital to effect the Islington extension that has been spoken about this long while.

CORRESPONDENCE.

Elieson Accumulator (British Patent) Syndicate, Limited, v. the Earl of Galloway, K.T.

Will you allow me a small space in your issue to correct an impression which has been created that I am connected in some way with the plaintiffs in this case. In July, 1892, I gave an option to acquire my patent for electric accumulators during a period only of 60 days, and upon the terms that a company should be formed having a subscribed capital of £6,000. Mr. Watson Smith registered the plaintiff company for that purpose, but the stipulated capital was never subscribed, nor were any directors appointed, and my offer consequently lapsed so long ago as October 17th, 1892.

On June 29th, 1893, a new company was formed under the title of the Lamina Accumulator (Elieson's British Patents) Syndicate, Limited, and the necessary capital subscribed. I have duly transferred my patent to the last-named company, of which the Earl of Galloway was, and is still, the chairman.

It is, therefore, the abortive company which brought the action against the Earl of Galloway, in which judgment has been given in his favour.

C. P. Elieson.

NOTES.

Government and the Telephones.—In the House of Commons last Friday, Mr. A. Morley, in reply to Mr. A. Morton, said that he could not state at what date it would be possible to lay the agreement between the Post Office and the National Telephone Company before the House. There were still some points to be considered, but there should be no delay in the matter.

Handy Batteries for Chemical Laboratories.—In a chemical laboratory, the inconveniences attending the use of primary batteries, such as Meidinger's, Bunsen's, bichromate, &c., become positive disadvantages. Secondary cells are excellent for many purposes when they can be easily charged, but few laboratories are fitted with even a small dynamo. To meet such cases Karl Elbs, in the *Chemiker Zeitung*, xvii., pp. 66, 97-98, recommends the adoption of small storage cells of the German Post Office type, which may be conveniently charged as required by means of Gülcher thermo-batteries. These yield an electromotive force of from 3·8 to 4·3 volts, according to the gas supply, little or no attention during charging being required. Elbs states that the cost is very trifling. Many chemists, who feel naturally drawn to the study of problems in which electricity bears a part, are kept from following out their bent on account of the inconveniences which have to be faced. Efforts should therefore be made to supply what is a recognised want, and Elbs's suggestion is in the right direction. Recently H. Frendenberg bore testimony as to the efficiency of the Gülcher thermopile in obtaining a constant electromotive force: he states (*Ziets. Physikalische Chemie*, xii., p. 97) that "at a tension of 4 volts it exhibited great constancy and small internal resistance, and, above all, rendered easy the possibility of withdrawing various large potentials."

Some Noteworthy Papers.—The following statements will illustrate the bearing of certain recent papers, which though of considerable interest, can scarcely claim more extended notice in these pages:—G. Staats, in the *Berichte* (xxvi., pp. 1,796-1,797), discusses the influence of frictional electricity on the formation of amalgams. He shows that if plates of silver in contact with mercury be subjected to the discharge from an electrical machine, the quantity of amalgam produced in a given time is increased threefold. In the *Monatshefte*, there is a paper (xiv., pp. 177—185) by W. Meyerhoffer, in which he considers the conditions of equilibrium in a saturated solution of a double salt, with one common ion when in contact with the salt in the solid state. The paper is illustrated by some instructive curves. The volume changes which water undergoes when different salts are dissolved in it in equivalent proportions with the formation of dilute solutions are found, on comparison, to be additive functions of the ions present in the salts. This is the text of a paper by M. Rogoff, in the *Zeitschrift für Physikalische Chemie*, xi., pp. 657—660. In the same number of the *Zeitschrift*, at pp. 829—831, there is a paper by G. Bredig, on the electrolytic dissociation of water. The author, from his own observations combined with the conclusions of Arrhenius, calculates that the quantity of hydrogen or hydroxyl ions contained in a litre of pure water is $0{\cdot}6 \times 10^{-6}$ gramme equivalents; this is a number which agrees well with those recently found by Ostwald, Wijs, and Arrhenius. "If two salts containing a common ion form at a given temperature n double salts, the latter and their components will at this temperature form at least $n + 1$, at most $Qn + 1$ saturated solutions of different composition." This rule is enunciated in a paper in the *Monatshefte*, xiv., pp. 165—175, by W. Meyerhoffer. F. B. Ebersbach deduces from the electrical conductivities of a number of acid solutions, their affinity coefficients, in a paper in the *Zeitschrift*, xi., pp. 608—632. Raoul Pickt showed a short time ago that all chemical action ceases at temperatures below -130° C. It is, however, possible, he states (*vide Comptes Rendus*, cxvi., pp. 1,057—1,060), to produce chemical action in a mass cooled to this temperature by furnishing to it energy from the outside, in the form, for instance, of electric sparks.

Some Electric Arc Experiments. — Since MM. Moissan and Froost, respectively, began to devote attention to the behaviour of various metals and other refractory substances in the electric arc and electric furnace, a number of interesting results have been obtained which from time to time have formed the subject of communications to the Paris Academy of Science. One of the most curious of these relates to the small spherulitic bodies which are frequently found on the inside of glass globes enclosing electric arc lights. These have been shown by Moissan to be identical in properties with the spherules of silica which are formed when silica is volatilised in an electric arc given by a current of 360 ampères and 70 volts. Zirconia also melts and boils at the temperature of this arc. Froost has put this observation to practical use. It has always been a matter of great difficulty to completely separate silica from zirconia, although the latter is more refractory than the former. Froost, however, has found that by mixing finely-powdered zircon with excess of finely-powdered carbon, and compressing the mixture into small cylinders, the silica will volatilise first, leaving the zirconia behind, when these cylinders are placed in a closed vessel filled with carbonic anhydride, and are then subjected to the action of a strong electric arc. Similar results are obtainable in the separation of silica from its compounds with the rare metal thorium.

St. Elmo's Fire.—The *Elekt. Zeit., Heft* 38, contains some notes on St. Elmo's fire, by J. Elster and H. Geitel, with reference to some experiments made by Peter Lechner at the Sonnblick Observatory during the period between July 20th, 1890, and June 30th, 1892, on 35 different days, with 670 separate observations. The chief object was to determine the sign of the electricity of the St. Elmo's fire. A metallic cylinder, insulated by ebonite, was placed outside the window of the observation room during a discharge, being connected for a moment to the earth by means of a wire. When the cylinder was taken into the room it was found to be charged, and the kind of electricity upon it was determined by a Bohnenberger's electroscope. The observer also estimated the extent of the effect by the intensity of the noise by which it was accompanied; he added, moreover, particulars as to the meteorological conditions, and remarks as to the colour of the discharge. It appears from these observations that although the St. Elmo's fire usually occurs as an accompaniment of thunderstorms, they are by no means always synchronous with them. Even in winter, with complete absence of snow and lightning, several manifestations of this curious phenomenon have occurred. But the majority of cases have taken place together with the falling of rain, hail, snow, &c. The exceptional displays are explained on the assumption that the storms were approaching or departing; in the former case the St. Elmo's fire commenced earlier, and in the latter it continued longer than the duration of the storm at the place of observation. As regards the sign of the charge, it is frequently reversing, especially at the occurrence of lightning. When there is no thunderstorm it may happen that the charge does not reverse, but reversal seems to be the rule. In winter, negative St. Elmo's fire is far more frequent than in summer. The nature of the fall of rain, hail or snow (*Niederschläge*) bears some kind of relation to the sign of the discharge. Large flakes of snow are accompanied by positive, and finer flakes by negative electricity; the former occurring more frequently in summer, the latter in winter. For hail and rain there is no perceptible difference of sign; nor has it been found that the direction of the wind influences it. The electrical potential of the atmosphere on the top of the Sonnblick corresponds, in some measure with the St. Elmo's fire; except that the sign is opposite, the reversals occur more or less together. It has been before observed on the Sonnblick that the displays are blue with negative St. Elmo's fire, and red with positive; this has been confirmed during the above experiments. Lastly, it has been suggested that the increased intensity of the manifestations on high mountains may, in part, be due to the reduced atmospheric pressure, which favours electrical discharge. On the Sonnblick it amounts to about two-thirds of an atmosphere. The writers have convinced themselves that the discharge between a blunt point and a plate at ordinary pressures (760 mm.) is not so pronounced as when the air is exhausted to 520 mm.

Earth's Magnetism in Russia.—Mr. Venukoff describes in an Academy paper the recent magnetic observations in Russia. The measurements were taken in Central Asia and European Russia. A very curious observation was made near Belgorod, where a variation sometimes as much as 180° was noticed in a space only several tens of kilometres square, thus indicating a kind of local pole. In other places variations in the declination were noticed up to 10° in a distance of 21 kilometres. This paper is reprinted in *L'Electricien*, September 30th, and a note is given of it in the "Digest" of New York *Electrical World*.

Pyro and Piezo-Electricity.—We have already noticed independent researches by Lord Kelvin and MM. Jacques and Pierre Curie, on the theory of pyro-electricity and piezo-electricity of crystals. In the November number of the *Philosophical Magazine*, pp. 453—459, Lord Kelvin returns to this interesting, if somewhat obscure, subject, and, by considering a few problems, succeeds in still further elucidating it. His work is a characteristic combination of the experimental with the mathematical, and full advantage is taken of the notion that an element of zinc and copper soldered together and surrounded only by air, as suggested by the brothers Curie, represents perfectly a true electro-chemical compound molecule in a realisable model. The ultimate result, however, arrived at by Lord Kelvin is, it must be admitted, rather appalling; for in idea he constructs a model for the piezo-electric and pyro-electric quality of a crystal in which each of twenty-one piezo-electric and pyro-electric coefficients has an arbitrarily given value.

Electrolysis as an adjunct to Medical Diagnosis.—While investigating some cases of supposed lead poisoning, Dr. Lee K. Frankel had occasion to require a method whereby this metal could be accurately detected in the urine. He consequently devised a modification of an electrolytic method recommended by Victor Lehmann, which, though it is by no means a very rapid means of detecting the poisonous metal, is, the time element being unimportant, an exceedingly accurate method. Lead salts, by the time they pass through the system and become components of the urine, are of such a composition that they cannot be decomposed by any but the strongest reagents. Good results, however, can be obtained, according to Dr. Frankel, by first oxidising the organic matter with potassium chlorate and hydrochlorate acid, and then depositing the lead in the form of peroxide on the positive electrode of a strong voltaic battery. This method is obviously time-consuming, but it offers the advantage that the whole of the lead present can be precipitated and quantitatively determined, if necessary.

The Pacific Cable.—The following is an extract from the *Canadian Gazette* of November 16th, 1893:—"Mr. Mackenzie Bowell is also, during his Australian tour, paying attention to the Pacific cable question. He has assured the Australian authorities that Canada has had, and will have, nothing whatever to do with the French cable; no line will receive Canadian support unless it is direct and under British control. Moreover, he has assured them that the subsidies which Queensland and New South Wales have given to the French cable need place no obstacle in the way of a direct line to Canada. Meanwhile, it is to be noted that the recent course of events has not passed unobserved in the United States, and we find the *Sun* of New York urging the United States authorities to lose no time in providing for a cable to Honolulu, with a view to its continuation to Japan. Having stolen a march upon British enterprise in the matter of the Pacific cable, France is, as we suggested the other day, surely pushing her way in the West Indies. It seems probable that the French Company which has secured the Queensland-New Caledonia cable will obtain further help from the French Government to complete its lines of communication to French colonies in the West Indies from Brest *via* St. Pierre Miquelon, or to the end of the French cable system at New York. Such a costly undertaking would be fresh proof that the French Government recognises the utility of keeping its cable communications in French hands. The *Matin*, moreover, tells us that it is the intention of the French Under Secretary for the Colonies to bring in a Bill for the laying of submarine cables connecting Madagascar and Réunion with the African continent."

Islington Electric Lighting.—A site for a central station has been agreed upon by the Vestry.

Crieff Electric Lighting.—Sir P. K. Murray has granted free use of the Barvick waterfall for generating electric light for the town.

Submarine Cables.—Messrs. Siemens & Halske have designed a new form of cable, with a view to increased speed. It is described in *La Lumière Electrique*, October 14th, and abstracted in the "Digest" of the New York *Electrical World*. It consists essentially in using a double wire cable for some distance at the middle of the line, the double portion acting as an inductive system. This method has been in use for some time between Suez and Aden.

Telegraph Steamer in Collision.—On Tuesday the steamer *Chiltern*, belonging to the Eastern Telegraph Company, arrived at West Hartlepool, and reported having been in collision off West Hartlepool, that morning, with an unknown vessel. It was very dark at the time, and nothing could be seen of the colliding ship. The bows of the *Chiltern* were damaged.

Propagation of Light in Metals.—In *La Lumière Electrique*, October 14th, M. Raveau describes his experiments upon the propagation of light in metals. He states that the velocity of light in silver is about four times as great as its velocity in vacuum, and that the dispersion is very slight; in gold and copper the velocity is also greater than in vacuum, and the dispersion is normal; in platinum, iron, nickel, and bismuth, the dispersion is quite normal. A short note is given in the "Digest" of the New York *Electrical World*.

The Electric Light in the City.—Colonel Haywood's report on the failures in the electric lighting of the City in the six months ending with October gives details of the hours and minutes in which any of the 479 arc lamps have ceased to burn. In all there have been 301 failures, the worst being on the 7th of May, when 42 of the electric lamps were extinct for periods ranging from an hour and a half to two hours and a-half. There were two smaller stoppages in June and July; but the majority were in single lamps for short periods, and Colonel Haywood says that "if the total number of hours the lamps failed be divided into the total number of hours that the whole of the electric lamps were burning during the six months, the percentage of time when the lamps failed is but small." The cost of each of the City lights is £26 a year, making a total for the brilliant lighting of the City streets of £12,454 per annum. "The 1,219 gas lamps, which are maintained ready for lighting, cost annually about £1,182."

Calories per C.P. of Various Sources of Light.—The *Elek. Zeit.* gives the following values, obtained by Mr. Dicke, for the quantity of heat generated per candle with different sources of light:—With bats-wing or fish-tail burners of 15 C.P., 50 calories; with Argand burners of 30 C.P., 44 calories; with a medium sized Siemens regenerative burner of 530 C.P., 23; with an Auer incandescent gas light of 50 C.P., 10·6; with another of 140 C.P., using water-gas, 6·7; for the electric incandescent lamp of 16 C.P., 3 calories. An abstract appears in the "Digest" of the New York *Electrical World*.

The Gale.—One of the results of the recent gale was the interruption of telegraphic and telephonic communication in various parts of the British Isles.

The *St. James's Gazette*, commenting upon the effects of the storm, says: "It is satisfactory to know that the lifeboats and rocket apparatus did excellent service all round the coast. But there is a boiling fury of surf which sometimes baffles even the hardiest lifeboat crews, such as those who ply opposite the Goodwin Sands, and this was the case at Margate, where the lifeboat could not be launched, and a telephone message had to be sent to the Broadstairs crew to get their boat out. The storm, by-the-by, has shown the great value of telephonic and telegraphic communication, so far as it has gone, along the coast, and the still greater value the system will have when it is completed."

Buxton Electric Lighting.—A provisional order is to be applied for by the Local Board.

The Closed Circuit Transformer.—According to Mr. Tanner, in *L'Industrie Electrique*, a transformer, with what was all but a closed circuit, was invented by a Frenchman in 1857.

Cheshire Asylum Electric Lighting.—Cheshire County Council are considering whether they shall extend the Asylum at an expenditure of about £80,000. £2,000 is estimated for the electric lighting.

Woolwich Electric Lighting.—The Local Board are considering whether to light the Town Hall, board room, and the new baths with the electric light. It has been decided to borrow £4,000.

Electrical Fatality at Grenoble.—At Grenoble, in France, recently, a contractor, who had got up on to a roof, touched the electric wires which were stretched naked on a post. He fell dead instantly. They belonged, we believe, to a distribution of 2,000 volts.

Harness and his Assistants at Marlborough Street Police Court.—This case was resumed before Mr. Hannay at the Marlborough Street Police Court yesterday. Dudley Towers was included in the charges of conspiracy. Mr. Lynd was examined at considerable length, the evidence showing that when witness knew Harness, there was no one in his employ who possessed the slightest knowledge of electricity. Mrs. Wilcocks, one of the prosecutors, gave evidence, and eventually the prisoners were remanded until next week.

The Electric Lighting of the Hotel des Téléphones at Paris.—It is known that the new Hotel des Téléphones has now been open some time; but this fact has not been made public, nor has any official inauguration taken place, as it was desired to avoid newspaper reports. The hotel was lighted by electricity at the same time by means of 250 16-candle incandescence lamps and 24 arc lamps. The installation is to be extended shortly to 500 incandescence lamps and 34 arc lamps. The electrical energy is supplied in continuous currents by the municipal station of the Halles. The mains consist of armoured cables encased in lead, laid directly on the ground.

Uses of the Phonopore.—The phonopore telegraph, which is in use on several of our railways, enabling them to send an extra independent message on the ordinary telegraph wire, in either direction, at the same time that telegrams are being sent by the ordinary telegraph, has made an additional claim to usefulness by the fact that communication has been maintained by its means under circumstances which rendered the ordinary telegraph altogether useless. It has happened lately on four different lines that, though the ordinary telegraph could not work on account of a breakage of the wire, the messages were sent by the phonopore just as if nothing unusual had taken place on the wire; the currents by which the phonopore is worked jumped the gap of the breakage, and thus kept up the communication whilst the ordinary telegraph was dumb.

Strike of Telegraphists in Italy.—A strike broke out the other day among the telegraphists of Rome, who complained of a recent law by which the salaries of those in the lower grades are reduced. As soon as the strike broke out on Monday the places of the strikers were partially filled, and telegrams were sent to all other offices informing the employés that the Roman strikers had given in. This unworthy artifice was detected, however, and the operators of other towns began to strike. Consequently a somewhat difficult position was created on Tuesday, although the Government had had time to provide a fresh staff in many of the offices. In Sardinia the strike was so complete that for 24 hours up to Tuesday night no news had been received thence in Rome. The women did not join the strikers, but they are said to have been so over-worked that many have fallen ill. Information in yesterday's daily papers was to the effect that the strike is practically at an end.

A Short Rule of Thumb.—A motor yielding a horse-power for every kilowatt consumed has an efficiency of 75 per cent.—"Hering" in the New York *Electrical World*. What a discovery!

The Regulations for Earth Returns. — We have received a copy of the draft regulations of the Board of Trade, which are suggested for the protection of electric wires against leakage currents from electric railways.

Explosion in Manchester Electric Light Mains.—Yesterday week an explosion occurred in one of the junction boxes at Manchester. Various reasons have been given, but the matter is being investigated.

Electric Traction in Paris.—A new electric tramway is about to be started on the line from the Porte Clignancourt to the Bastille. Like the previous ones, this tramway is worked by accumulators supplied by the Société Electrique des Métaux, placed under the seats. The same kind of car has been adopted.

The Royal Society.—The following papers were down for reading before this society yesterday afternoon:—"On the Photographic Arc Spectrum of Electrolytic Iron," Prof. Lockyer, F.R.S.; "Magnetic Observations in Senegambia," Prof. Thorpe, F.R.S., and P. L. Gray; "Alternate Current Electrolysis," Dr. Hopkinson, F.R.S., E. Wilson, and F. Lydall.

An Electrified Roadway in Paris.—A short time ago, in the Boulevard des Italiens, opposite the Café Riche, a sensation was caused by an incident which is of somewhat frequent occurrence. A wire belonging to the electric lighting system broke, and established free contact with the earth. On reaching this point, the horses received a shock and refused to proceed further. The scene was very curious. The broken wire was immediately replaced.

NEW COMPANY REGISTERED.

Gorseinon Electric Light Company (39,944).—This company was registered on the 17th inst. with a capital of £1,000 in £1 shares, to carry on the business of electric lighting in all its branches; and to lay down all necessary cables, &c., and supply electricity to light buildings and places both public and private, and works in and about the town and environs of Gorseinon, near Swansea. The subscribers (with one share each) are: W. K. Lewis, Gorseinon, tinplate manufacturer; T. Lewis, Gorseinon, tinplate manufacturer; T. Jones, Gorseinon, grocer; T. V. Thomas, Gorseinon, draper; T. Mitchell, Gorseinon, surgeon; Wm. Thomas, Gorseinon, tailor; J. Richards, Swansea, solicitor. Table A mostly applies. Registered by Jordan & Sons, 120, Chancery Lane, W.C. Registered office, Gorseinon, Glamorgan.

CONTRACT OPEN.

Dublin.—December 14th. For the extension of the buildings and the supply and erection of additional plant at their central station, Fleet Street, Dublin, for the Corporation of Dublin. Plans may be seen, and specifications and forms of tender obtained, at the office of Mr. Spencer Harty, C.E., city surveyor, City Hall, Dublin.

BUSINESS NOTICES, &c.

The Universal Electrical Directory (J. A. Berly's), now under the direct supervision of the proprietors, H. Alabaster, Gatehouse & Co., is in active preparation for the 1894 edition (13th year). This is a directory of the electrical trades embracing the whole Universe, and having no superfluous matter irrelevant to a directory it can be sent everywhere, carriage paid, for 4s. It is indispensable to all having business transactions in the electrical world, and once used cannot be done without. Advertise in it! Order it! It will prove the best outlay ever made.

Provisional Orders.—The following applications to be made for electric lighting powers to the Board of Trade during the 1894 session, have been officially announced in the *London Gazette*:—

Plymouth.—Application by the Corporation for power to produce, store, and supply electricity within the borough of Plymouth.

Penrith.—Application by the Local Board for power to produce, store, and supply electricity within the district of the Local Board, and so much of the district of the West Ward Rural Sanitary Authority as is comprised in certain portions of the parish of Brougham and the township of Yanwath and Eamont Bridge, in the parish of Barton, in the county of Westmorland.

Chelmsford.—Application by Crompton & Co., Limited, for power to produce, store, and supply electricity in the borough of Chelmsford.

Monmouth.—Application by the Corporation for power to produce store, and supply electricity within the borough of Monmouth.

Chepping Wycombe.—Application by the Corporation for power to produce, store, and supply electricity for public and private purposes within the borough of Chepping Wycombe.

Swansea.—Application by Crompton & Co. for power to produce, store, and supply electricity within the borough of Swansea.

Chesterfield.—Application by the Corporation for power to produce, store, and supply electricity for public and private purposes within the borough of Chesterfield.

Crystal Palace and District.—Application by the Crystal Palace District Electric Supply Company, Limited, for power to extend area of powers and provisions of their 1890 order.

St. Helen's.—Application by the Corporation for power to supply electricity within the borough of St. Helen's.

Kensington.—Application by the Vestry for power to produce, store, and supply electricity within the parish of St. Mary Abbotts, Kensington.

Wakefield.—Power to the Corporation to produce, store, and supply electricity within the city of Wakefield.

Barrow-in-Furness.—Power to the Corporation to produce, store, and supply electricity within the borough of Barrow-in-Furness.

Grimsby.—Power to the Urban Sanitary Authority to produce, store, and supply electricity within the borough of Grimsby.

Plymouth and Stonehouse Gas Light and Coke Company intend applying for power to produce electricity and other illuminating power.

Central London Railway.—Extension of time for purchase of lands and for completion of the railway. To amend Acts especially relating to the acquisition of subsoil and the use of electric power.

Bristol and Electric Tramways.—The St. George's Sanitary Authority have received a letter from the Bristol Tramways Company saying that the directors had now satisfied themselves that they could with every confidence ask the board to approve the working of the St. George's line, together with the extension to Kingswood, by electric traction. He would, within the next two or three weeks, forward a formal application to the board, and send to each member a complete report, with sketches, showing the details of the proposed motive power. In order to carry out the line it would be necessary to go to a large expense in acquiring frontages in various parts of the road for the purpose of road widening, and the little alterations which the directors ask the board to carry out in the improvement of footpaths involve a small expenditure when compared with the large amount which the company would have to lay out in the widening of the roads in the district. In order that the parliamentary notices might not fall through this year, he had therefore to ask the board to be good enough to pass a resolution approving the alteration to the footpaths, and that resolution would, of course, be subject to their subsequent approval of the general proposals of the company, which would be in due course placed before them. The motion to accede to the application was unanimously adopted.

Harrogate Electric Lighting and Refuse Destruction.—The Sub-Committee along with Mr. Wilkinson, consulting engineer, and the borough surveyor report that they inspected refuse destructors at Bradford, Halifax, and Leeds, with a view to the utilisation of the refuse in connection with the raising of steam for an electric lighting installation, and it was resolved: "That Mr. Wilkinson be empowered to have two trucks of ashpit refuse, if he so requires, for the purpose of testing, Mr. Wilkinson to make personal tests with the material, and afterwards to further investigate and report to this committee the feasibility of utilising a refuse destructor for the purpose of electric light, and for the pumping of sewage." The Town Council have agreed to this.

Stafford Infirmary Lighting.—The Board of Guardians Committee have examined the tenders for fixing electric bells in the new infirmary at the house, and recommend the acceptance of the tender of Messrs. Holmes & Ladbury for £19 10s., which included the cost of telephonic communication with the hospital nurse and the master's office. The tender has been accepted by the Guardians.

Electric Lighting of the Royal Exchange.—The ceremony of turning on the electric light at the Royal Exchange, which work has been carried out by Messrs. J. G. Statter & Co., took place yesterday (Thursday, the 23rd inst.), at 3.45 p.m. The Lord Mayor was present and personally performed the ceremony of turning on the electric light for the first time.

Globe Telegraph and Trust Company.—The secretary of this company has written to the financial papers as follows:—"A misleading circular, signed "Scrutator," has been addressed to some of the shareholders of the Globe Telegraph and Trust Company, Limited, insinuating that the present value of its assets shows a deficiency in its capital account, and I am directed to ask you to be good enough to publish the following:—The directors yesterday caused a valuation to be made of the securities held, and this shows a present surplus market value over the paid-up capital of the company of close on £300,000. I beg to enclose you a copy of the balance-sheet of July 18th, 1893, and you will find attached thereto full details of the company's investments, which have not since been varied. The values of all but two or three comparatively small investments are quoted daily, and it will be easy for any shareholder to satisfy himself of the accuracy of the above-mentioned valuation. At the same time I am instructed to say that the directors do not consider the market prices of the securities they hold as being the only criterion of their values." "Shareholder" has since written to the *Financial News*, as follows:—"At the last meeting of this company, I made the suggestion that the current value of the company's various holdings should be published with the annual balance-sheets. My reason for so doing was that having valued out the stocks at the then current prices, I had been gratified to find that they totalled up nearly £500,000 over their cost value, and it appeared to me that such a piece of information would be agreeably received by the shareholders at large. The chairman considered that the printing of the valuation would be impolitic, and I accepted his opinion without question. The circular issued by "Scrutator"—which, by the way, I have not seen—seems, however, to show that it is not quite undesirable. The lesser amount which the secretary now quotes as the excess value (£300,000) is, no doubt, largely due to the recent fall in Anglo-American stock."

Bankruptcy.—The following is a list of the creditors of Chas. Henderson Millar, formerly trading as an electrician, at 15, College Street, Belfast:—

Baird, W. & G., Belfast	£7	19	1
Beaton, Charles, Belfast	5	13	0
Bowden Cycle Co., Ltd., Belfast	8	0	0
Johnston, B. & Co., Belfast	7	10	0
McVeigh, S. & Co., Belfast	11	8	0
Ward Marcus & Co., Ltd., Belfast	11	13	6
Curtis Bros., Dublin	20	2	6
General Electric Co., Ltd., Glasgow... ...	52	8	7
Gent & Co., Leicester	23	0	0
Consolidated Telephone Co., Ltd , London...	15	11	3
Edison & Swan United Co., London ...	14	13	3
Ford-Lloyd Mfg. Co., Ltd., London... ...	12	10	8
Woodhouse & Rawson United, Ltd., London	45	0	0
Sundry creditors under £5	22	19	1
Total	£258	8	11

Telephones at Liverpool Waterworks.—Telephonic communication has lately been established for the Corporation of Liverpool, connecting the offices of the water engineer in Dale Street, Liverpool, with the water supplies of Lake Vyrnwy (Montgomeryshire), the Rivington Reservoirs (North Lancashire), and the houses of the reservoir keepers and walksmen along the lines of the aqueducts. The work has been carried out to the specification of the City Water Engineer (Mr. J. Parry, M.Inst.C.E.), and affords a very ready means of communication between all points of the water supplies. The contract for the complete installation was placed in the hands of Messrs. W. A. Shaw & Co., electrical engineers, of Warren Street, Stockport, and has been carried out by them under the personal supervision of the partners, to the entire satisfaction of Mr. Parry. The system is entirely on the metallic circuit principle, and the wires are carried as nearly as possible along the lines of aqueducts. In addition to the telephonic communication there are also alarm contacts to valves and for overflows, ringing bells at the nearest signalling station.

Catalogues, Lists, &c.—From Messrs. Browett, Lindley and Co., Limited, of Manchester, we have received a copy of the vertical section of their illustrated catalogue of high-speed engines for electric lighting and transmission of power. The illustrations, which are all large ones, are some of the best specimens of engraving we have seen in catalogues The book, which contains about 20 pages, is altogether an excellent piece of work, the printing and also the quality of the paper being of the first class. Messrs. Browett, Lindley have been very busy of late. They have nearly completed the whole of the engines for Derby Corporation Electricity Works, and having on order (besides many others) all the engines for Ealing central station, the engines for Coventry electric trams, three engines for the electric lighting of the Palace of the Shah of Persia, a 150 H.P. engine for lighting a portion of Messrs. Howarth's mills, an engine for the Lancashire and Yorkshire Railway Company, &c., &c.

Boiler Insurance.—The Scottish Boiler Insurance Company, of Manchester and Glasgow, have issued a useful manual for steam users on the subject for boiler explosions, illustrated with views of representative disasters that have occurred through external corrosion, shortness of water, lamination, seam rip or structural weakness. The necessity of having steam boilers periodically inspected is shown to be as urgent as ever, for although great advances have been made in the quality of the materials used in making boilers, and in the workmanship, it has also to be remembered that the loads on the safety valves are very much higher within recent years, and as the tendency is still in that direction, it becomes more than ever the duty of boiler-makers, inspectors, and steam users, to see that these magazines of useful energy are not allowed to become engines of destruction. The publication is full of useful hints and will, we presume, be sent free to any applicant.

Accumulators.—Mr. W. S. Sargeant, of the Thames Electric and Steam Launch Company, writing to us regarding our recent notes *re* the cells in use on the Birmingham Central Tramway Company, says that he built and equipped an electrical launch for Mr. Andrew Pears, in 1889 (about which we have already published several notices). The battery consisted of 32 cells, E P.S. B-type, 15 plates, in open ebonite boxes. The same battery is in use at the present time in this launch, and is giving satisfactory results; further, he states "it has never been repaired in any way whatever." This launch (the *Pilot*) is now alongside the above company's works, at Eel Pie Island, and can be inspected.

The Brighton and Rottingdean Electric Railway.—The project for the construction of this electric railroad is in a fair way of being carried out, and under favourable circumstances it is expected that it will be completed by next Whitsuntide. The company, formed under the title of the Brighton and Rottingdean Seashore Electric Tramroad Company, has just issued for private circulation a prospectus from which it appears that 1,200 shares of £10 each are about to be issued. The directors have decided to take up £4,000 as ordinary shareholders, and the promoters have consented to receive 232 fully paid up shares, leaving the remainder for private investors, no public appeal whatever for support being made.

United Telephone Company of Rosario, Limited.—A general meeting of the members of this company will be held at the registered offices of the company, 78, Coleman Street, E.C., on December 18th, 1893, at 12 o'clock noon, for the purpose of having an account laid before them, showing the manner in which the winding up has been conducted, and the property of the company disposed of, and of hearing any explanation that may be given by the liquidator; and also of determining, by extraordinary resolution, the manner in which the books, accounts, and documents of the company, and of the liquidator thereof, shall be disposed of.

Drake & Gorham.—Among the many installations which this firm have in hand may be mentioned 29, Mincing Lane for Mr. C. Czarnikow for whom they reconstructed and re-modelled his country house installation at Effingham some years back, which has given entire satisfaction. As the result of this work they have been entrusted with the large extensions which are being carried out at 103, Eaton Square for Mr. Czarnikow, as well as his city offices. The firm have also been called in to take out and re-wire the whole of the installation at Westwood House, Sydenham, for Mr. C. J. W. Rabbits; in this case there are about 200 lights.

New Atlantic Cable.—The Commercial Cable Company have signed a contract with Messrs. Siemens Brothers & Co., for the manufacture of a new Atlantic cable, to be laid between Ireland and Nova Scotia in the ensuing spring. This cable, which will be the third one owned by the Commercial Cable Company, will be 2,200 miles in length, and is to be made to a specification ensuring greater carrying capacity than any cable of the same length. It will also be of special strength in order to resist ships' anchors in fishing waters.

The Electric Light at Berwick.—On Wednesday evening last week the second installation (50 volts) of electric lighting in Berwick was introduced by the firm of Messrs. Lamb and Son, at the premises of Messrs. Ross Brothers, butchers, Hide Hill. The dynamo is placed in the rear of the premises, and is by Messrs. Gent of Leicester. It is driven by a four horse power vertical engine. The shop and offices are illuminated by 13 incandescent lamps.

Balham and Electric Lighting.—The Wandsworth Board of Guardians the other day received a letter from Mr. Peton Dashwood, applying for permission to erect six iron columns close to the kerb in front of his shops at Balham High Road, and to lay iron tubing with the necessary connection in such columns for the purpose of electric lighting. After discussion the Guardians did not appear to know what to do in the matter, so they referred it to a committee for consideration.

The Electric Light in Halifax.—The notice given by the Halifax Mutual Electric Lighting Company to their customers of an intention to discontinue the supply has almost expired. We understand, however, that users of the electric light in the town have made an offer to the company with a view to purchasing the plant and continuing the light. Though the offer has not been accepted, arrangements have been made for continuing the light for at least 14 days longer.

Crossley Brothers.—At Norwich Fat Cattle Show Messrs. Crossley Brothers, Limited, have a stand in the West Gallery, where is to be seen a small B.A. electric light engine and dynamo combined. The engine (high-speed) is of about 2½ actual horse-power, and the dynamo, which rests upon the same bed, will produce 20 16-candle-power incandescent lamps. The installation was fitted up by Messrs. A. Pank & Son, Norwich.

Sunderland Electric Lighting Tenders.—A special meeting of the Corporation Highways Committee was held last week for the express purpose of considering the tenders for the electric lighting works. The committee found that very few less than a hundred packages of tenders had been received, and as these could not possibly have been got through, a committee was appointed to consider and report.

Personal.—We learn that Mr. J. D. Bailie, late installation superintendent for Messrs. J. D. F. Andrews & Co., London, S.W., has been appointed Yorkshire representative for Messrs. C. A. Parsons & Co., electrical engineers, Newcastle-upon-Tyne, whose Yorkshire offices are situated at Peacock's Buildings, Park Row, Leeds.

The Electric Light at Faversham.—Mr. Henry S. Tett, ironmonger, has had the whole of his extensive premises in Market Street—shops, show-rooms, warehouses, workshops, and yard—brilliantly illuminated by electricity. The system of wiring adopted is Andrews' patent. The lighting plant consists of an eight horse-power Otto gas engine, a Crompton's continuous current dynamo, and a battery of accumulators. Over sixty lamps, of eight, sixteen, and fifty candle-power have already been fixed, and others are in course of preparation.

The Electric Light at Whitehaven.—Mr. J. G. Dees, the chairman of the Whitehaven Trustees, states that last week all the lamps of the town and harbour, 49 in number, were lighted by electricity. They had connected for domestic supply 500 16-C.P. lamps, and had application for 300 more.

Brewery Lighting.—Mr. Murfin's brewery and business premises at Great Staughton have been lighted by electricity. In addition to the usual generating and distributing plant, the installation includes a set of accumulators. The installation has been carried out by Messrs. J. Bennett & Sons of St. Neots.

Felten & Guilleaume.—We have received from this firm a large reproduction of a photograph of 33,000 yards of wire rope 5½ inches circumference and 210 tons weight, manufactured by them. The illustration shows the rope laden in one length on 8 eight-wheel bogie trucks.

Electric Light Station Destroyed by Fire.—The Halifax Electric Company's supply station was burned down yesterday. The damage is covered by insurance.

Electric Light at Gateshead.—The Gateshead Co-Operative Society have decided to light the whole of their extensive establishment in Jackson Street by electricity, and also their new premises now approaching completion in Whitehall Road.

Electric Lighting of Chatsworth.—The electric lighting of Chatsworth, which was entrusted to Mr. Bernard Drake by the the Duke of Devonshire, has been successfully completed and the whole plant started without a hitch of any kind.

Electric Light at Moss Side, Manchester.—The Local Board have resolved to request the Collier-Marr Company to withdraw their application for a provisional order. Otherwise, the Local Board will oppose the application.

Infirmary Electric Lighting.—The City of London Union have resolved to empower their engineer at a fee not exceeding £10 10s. to advise the committee as to the installation of electric light at the infirmary.

Ilkley and Electric Lighting.—Mr. E. H. Wade, of Sedbergh House, has had his residence equipped with the electric light, the work having been satisfactorily carried out by Messrs. Andrews & Preece, Limited.

Cheltenham Electric Lighting.—Last week an enquiry was held by the Local Government Board into the application by the Corporation for leave to borrow £16,000 for the purposes of electric lighting the borough.

Electric Light at Eastwood.—Messrs. Moss Brothers have fitted up their Bridgeroyd fustian cutting works, a new building just erected, with electric light. The work has been carried out by Mr. R. S. Blackburn.

Ship Lighting.—Messrs. James and George Thomson, Clydebank, have opened an electric department in their shipbuilding yard. They will henceforth do all the electric fitting of ships built by themselves.

Lectures.—Under the auspices of the Dundee and North of Scotland Institute of Mechanical Engineers, Mr. James B. Coor delivered an address in the Technical Institute last week on "Electrical Machines."

Battersea Polytechnic Institute.—The governors are inviting applications for several appointments. Teachers are wanted for a number of subjects, particulars of which appear among our advertisements.

Manchester and the Telephone.—The Parliamentary Sub committee, appointed by the Corporation, have lately presented a somewhat lengthy report regarding the telephone question at Manchester.

St. Asaph and Electric Lighting.—It is rumoured that a firm of Cardiff electricians are negotiating with some of the principal tradesmen to have the city lighted with electricity.

Agency.—Mr. Fernand Espir has recently taken up the sole agency of Messrs. Lazare, Weiller & Co. (of Paris), manufacturers of high conductivity electrical and other copper wires.

Change of Address.—Messrs. Woodhouse & Rawson United, Limited, have removed their Glasgow office to larger premises at 12, West Campbell Street, Glasgow.

Exhibition Lighting.—The Industrial and Fine Arts Exhibition, at Oban, is lighted by electricity by the Caledonian Electric Supply Company.

Electric Organ.—A new electric organ, built by Mr. J. Murgatroyd, was opened on Saturday last at Heaton Parish Church, Bradford.

CITY NOTES.

Elmore's Patent Copper-Depositing Company, Limited.

THE coal strike has much to answer for, but amongst the most serious evils laid to its door may be included the "frustration of all the efforts" of the directors of Elmore's Patent Copper Depositing Company to arrive at prosperity. In the report for the year ended June 30th, the directors state:—"A steady trade is being done in coating hydraulic rams and building up calico rollers. The delay caused by the coal strike has been very hard on the resources of the company, which were, at best, barely adequate, as shareholders will remember; besides which, several considerable payments have had to be made to meet liabilities incurred by the old board, and which did not appear in the books and could not have been included in the estimates submitted by the present directors; consequently, if a large trade is to be done, more money will be required to restore sufficient capital for furnishing the £10,000 worth of copper originally stated as being necessary. It will be evident that before dividends can be paid, even on the preference shares, it will be necessary to write down the value of the ordinary shares, so as to wipe off the amount standing to debit of profit and loss. As an extraordinary general meeting of the shareholders will be required to carry out the necessary resolutions, the directors intend taking the needful measures for that purpose." The loss for the year is £13,655, which, added to the debit balance of £7,862 as at June 30th, 1892, makes the total loss £21,517. The books show orders on hand for 126,048 lbs., against 28,391 lbs. at June 23rd, or, say, 56 tons against 12½. Wonderful!

Telegraph Construction and Maintenance Company, Limited.

THE directors of this company have advertised their intention to renew the existing debentures, which mature on January 1st, 1894, with debentures to an equal amount, to mature on January 1st, 1899, and upon which interest will be payable half-yearly at the rate of £5 per cent. per annum. They further state that holders of the existing £5 per cent. debentures on leaving their debentures, or any of them, at the office of the company, 38, Old Broad Street, London, E.C., between December 15th and 31st, 1893, can have such debentures exchanged on and after January 8th, 1894, for an equal amount of £5 per cent. debentures. Existing debentures not lodged with the company before December 31st, 1893, will be paid off in cash, according to their tenour, on presentation at the company's bankers, Messrs. Barclay, Bevan, Ransom & Co., 54, Lombard Street, E.C. The directors reserve to themselves the right at their discretion on and after January 2nd, 1894, to dispose of all £5 per cent. debentures not required for exchange with existing debentures.

The Continental Edison Company at Paris.

SPEAKING generally, there is little to be said about the Paris electrical companies as regards their financial and commercial position. We have, however, received some information concerning the Continental Edison Company, which we think may be worth recording. The original capital of the company was 1,000,000 francs, divided into 400 shares of 2,500 francs each. The capital was, however, increased to 7,000,000 in 1887, and to 10,000,000 in 1889. Up to 1892, the company possessed works at Ivry for the manufacture of the machines and apparatus. In 1892, the patents and drawings of the dynamos were sold to the Electro-Mechanical Company, and the Edison Company then devoted itself solely to electrical installations and the sale of electrical energy. The company's offices are now situated at 28, Rue de Châteaudrin; they possess three central stations: the station of the Faubourg Montmartre, the station of the Avenue Trudaine, and the station of the Palais Royal. A smaller regulating station has been established with accumulators in the Rue Saint-Georges, close to the company's offices. The two first stations are connected in quantity for supplying the sector granted to the company in 1888, one of the most important in Paris. It includes many of the Boulevards, and we find within its area all the theatres and nearly all the large cafés and restaurants in Paris. The Palais Royal station lights the Palais de l'Elysée, the Jardins du Carrousel, and the Jardins du Palais Royal. The company also undertakes the lighting of several theatres by means of private stations established at various points, for instance, the Opéra and the Odéon. The central station of the Faubourg Montmartre, which is the oldest, is now attaining its maximum discharge; in 1888 it supplied 3,863 lamps, in 1889 11,493 lamps, in 1890 23,093 lamps, in 1891 29,782 lamps, in 1893 43,942 lamps, and in March, 1893, 58,278 lamps. As we see, the Edison Company has up to the present prospered in Paris; it is now necessary, in order to favour the development of electrical industry that the Municipal Council of Paris should extend the duration of the concessions of sectors.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending November 19th, 1893, amounted to £879; week ending November 20th, 1892, £899; decrease £20; total receipts for half-year, 1893, £16,425; corresponding period, 1892, £16,244; increase £181.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending November 17th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,115.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.‡	Closing Quotation, November 15th.	Closing Quotation November 22nd.	Business done during week ended November 22nd, 1893. Highest.	Lowest.
184,500*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	100 —103	100 —103	100½	...
1,134,640*l*	Anglo-American Telegraph, Limited	Stock	45 — 47	44 — 46	45	...
2,932,680*l*	Do. do. 6 p. c. Preferred	Stock	85 — 86	83 — 84	85⅞	82½
2,932,680*l*	Do. do. Deferred	Stock	7¾ — 8¼	7⅞ — 8¼	7⅞	...
130,000	Brazilian Submarine Telegraph, Limited	10	11⅜ — 12¼	11⅜ — 12¼	12 1/16	11¼
18,700*l*	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	107 —111	107 —111	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	2⅞ — 3	2⅞ — 3	2 15/16	2 13/16
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2⅛ — 2⅜	2⅛ — 2⅜	2⅜	2 5/16
125,000*l*	Do. do. 4½ per cent. Debenture Stock	Stock	106 —108	106 —108	...	...
20,510	Charing Cross & Strand Electricity Supply Nos. 1 to 6, 215 to 718, and 10,001 to 30,000	5	4⅜ — 5¼	4⅜ — 5¼	...	...
44,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	2 — 3	2 — 3	...	...
630,000*l*	City and South London Railway	Stock	28 — 33	28 — 33	...	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	11¼ — 11⅝	11¼ — 11⅝	...	...
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	12⅜ — 13¼	12⅜ — 13¼	13	...
10,000,000$	Commercial Cable, Capital Stock	$100	140 —150	140 —150	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	10/-	1/16 — 3/16	1/16 — 3/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	4¼ — 4⅝	4¼ — 4⅝	4⅜	...
50,000*l*	Do. do. 5 p. c. 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	96 —101	96 —101	...	...
16,000	Cuba Telegraph, Limited	10	11½ — 12½	11½ — 12½	...	...
6,000	Do. do. 10 p. c. Preference	10	18 — 19	18 — 19	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2½ — 3½	2½ — 3½	...	...
6,000	Do. do. 10 p. c. Preference	5	8½ — 9½	8½ — 9½	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅛ — 11⅜	11⅛ — 11⅜	11⅜	11¼
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜ — 15	14⅜ — 15	15	14¼
70,000	Do. 6 p. c. Preference	10	15½ — 16½	15½ — 16½	15⅝	...
105,900*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	108 —111	108 —111	...	...
1,294,100*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	113 —116	113 —116	...	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	15⅛ — 15⅜	15⅛ — 15⅜	15⅜	15⅛
62,700*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	102 —105	102 —105	...	...
222,800*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	113 —116	113 —116	...	...
108,700*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104	102 —105	103¼	102½
146,800*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	101 —104	102 —105	103¼	...
300,000*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	101 —104	102 —105	104	...
200,000*l*	Do. 4 p. c. Reg. Mt. Debs. (Mauritius Subsidy) 1 to 8,000	25	104 —107 %	104 —107 %	106½	104
49,900	Electric Construction, Limited, Nos. 101 to 45,100	10	1⅜ — 2¼	... ...	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ...	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	⅛ — ¼	⅛ — ¼	...	...
91,195	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	⅛ — ⅜	¼ — ⅜	...	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	¼ — ⅜	¼ — ⅜	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	½ — 1½	½ — 1½	...	...
180,227	Globe Telegraph and Trust, Limited	10	8¼ — 8½	8⅜ — 8⅝	8⅝	8¼
150,042	Do. do. 6 p. c. Preference	10	14⅝ — 15⅛	14⅝ — 15⅛	15⅛	14 13/16
150,000	Great Northern Tel. Company of Copenhagen	10	20 — 20½	20 — 20½	20⅝	20 3/16
200,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	103 —106	103 —106	105½	...
12,134*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½ — 5½	4½ — 5½	...	...
9,600*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	6 — 7	6 — 7	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21 — 22	21½ — 22½	21 15/16	21⅝
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	40 — 43	40 — 43	41¼	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	1 — 2	1 — 2	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	4½ — 4½	4½ — 4½	4 7/16	4 7/16
15,000	Do. do. fully paid	5	6½ — 6⅝	6 3/16 — 6 7/16	6½	5⅝
37,500	Liverpool Overhead Railway Ordinary, fully paid	10	5⅛ — 5⅜	5⅛ — 5⅜	8¼	4⅜
6,295	Do. do. Pref., £6 paid	10	6⅛ — 6¼	6 1/16 — 6 3/16	6⅜	...
37,548	London Platino-Brazilian Telegraph, Limited	10	4 — 6	4 — 6	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	105 —108	105 —108	...	..
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	7¼ — 7⅜	7¼ — 7⅜	7⅝	7 7/16
50,000*l*	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	106 —109	106 —109	108	107⅝
15,000	Monte Video Telephone Co., Ord., Nos. 1 to 15,000 fully paid ...	5	1½ — 2½	1½ — 2½	...	...
28,000	Do. do. 6 p. c. Pref., Nos. 1 to 28,000 fully paid	5	3 — 4	3 — 4	...	...
484,597	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜ — 5	4⅜ — 5	4 15/16	4⅞
15,000	Do. 6 p. c. Cum., 1st Preference	10	14 — 15	14 — 15	14⅜	14⅛
15,000	Do. 6. p. c. Cum. 2nd Preference	10	13½ — 14½	13½ — 14½	14	...
119,234	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	5¼ — 5½	5¼ — 5½	5 7/16	5⅜
726,477*l*	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	113 —115	113 —115	114½	113‡
48,800	New Telephone, Limited, Nos. 25,901 to 74,700 ... * (£2 paid)	10	... ...	... ...	...	...
6,452	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	5 — 6	4½ — 5½	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	1/16 — 5/16	1/16 — 5/16	...	...
100,000*l*	Pacific and European Tel., Ltd., 4 p. c. Guar. Debs., Nos. 1 to 1,000	100	102 —105	102 —105	...	...
11,802	Reuter's Limited	8	5½ — 6½	5½ — 6½	...	...
19,980	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	6 — 6¼	6 — 6½	6 5/16	...
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	8 — 8½	8 — 8½	8 7/16	8 1/16
3,381	Submarine Cables Trust	Cert.	113 —118	113 —118	...	...
78,942	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	2 — 2¼	2 — 2½	2⅜	...
37,350	Telegraph Construction and Maintenance, Limited	12	34 — 36	35 — 37	36½	35½
150,000*l*	Do do. do. 5 p. c. Bonds, red. 1894	100	101 —104	104 —107	107	...
58,000	United River Plate Telephone, Limited	5	2 — 2¼	2 — 2½	...	...
146,370*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	90 — 100	90 —100	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	5½ — 6½	5½ — 6½	...	...
260,900*l*	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101	99½	98½
30,000	West Coast of America Telegraph, Limited	10	2 — 3	2 — 3	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	99 —103	99 —103	...	...
64,242	Western and Brazilian Telegraph, Limited	15	5½ — 6¾	5½ — 6½	6¼	6
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5¼ — 5¾	5½ — 5¾	...	...
33,129	Do. do. do. 5 p. c. Deferred	7½	1 — 1½	1 — 1½	...	...
178,200*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
222,700*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	..
88,321	West India and Panama Telegraph, Limited	10	1½ — 1⅝	1½ — 1⅝	1 3/16	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10 — 10½	10 — 10½	...	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	9 —10	9 — 10	...	...
80,000*l*	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	107 —110	107 —110	110	109
$1,214,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	113 —118	113 —118	...	..
169,000*l*	Do. do. 6 p. c. Sterling Bonds	100	102 —105	102 —105	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	5½ — 6	5½ — 5⅝	5½	...

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—6¼.—Brush Company, 4½ per cent. Debenture Stock, issued at 1 per cent. premium, 107—109.—Electric Construction Corporation 6 per cent. Debentures, 8⅛—12.—Electric and General Investment, shares of £5 (£1 paid), 1¼—2½.—Founders' shares, 200—225.—Electricity Supply Corporation, Ordinary of £5, 5—5¼.—House to House Company (£5 paid) 1—2.—Do. 7 per cent. Preference of £5, 4¾—5¼.—Do. 6 per cent. Debentures of £100, 97—102.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 4¾—5½, 1st Preference Cumulative 6 per cent., £5 (fully paid), 6¼—7.—Liverpool Electric Supply, £5 (fully paid) 6⅛—6¼.—Do. £3 10s. paid, 4⅛—4¼.—London Electric Supply Corporation. £5 Ordinary, ⅞—1⅛—Manchester Edison and Swan Company £5 (£1 paid), 1—1⅛.—Queen Anne's Mansions Lighting and Heating 6 per cent. £100 Debentures, 101—103.

Bank rate of discount, 3 per cent. (October 5th.)

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

THE ELECTRICAL TRANSMISSION OF POWER FROM NIAGARA FALLS. By Prof. GEORGE FORBES, F.R.SS. (L. & E.), member. Read November 9th, 1893, and discussed on November 23rd.

I had originally intended the title of this paper to be "The Transmission of Power by Electricity," but I found on writing it that it was inevitable that the work on which I am engaged as electrical consulting engineer at Niagara Falls should take a very prominent part in its substance; but the paper does still deal with the general question.

On December 14th, 1892, I read before the Society of Arts a paper on the utilisation of Niagara Falls, in which the general plan of operations was described. But at that time the electrical developments were not sufficiently advanced to enable me to treat of that part of the subject. A reference to that paper will prevent the necessity of my wasting time in describing in detail the civil engineering and hydraulic arrangements. The object of the present paper is to put before this Institution the circumstances under which this great problem has been attacked, and the views which have been arrived at, and also to describe, so far as any work has been done, the electrical machinery to be installed.

I have simply followed the logical conclusions that were to be derived from the past experience; and in this I have been benefited by the courtesy and kind assistance of professional men, inventors, and manufacturers in both continents, who, almost without exception, have put their experiences at my disposal. If I have been the instrument to put before the company any designs of value, it has been to a great extent as the assembler of ideas which have originated as often in the minds of the engineers and draughtsmen who have given me their assistance, as in my own. I wish especially to express how much the company is indebted to Prof. Coleman Sellers, one of the most distinguished mechanical engineers in the United States, and who has assisted me throughout with his advice and suggestions, and who may be said to have originated the form of bearings and their supports which are to be used in the Niagara dynamos. I have also received valuable suggestions from my colleagues, Prof. Unwin and Colonel Turrettini, and also from the draughtsmen who have assisted me, and from numerous friends in our profession. I have been desired by the president of the company to take this opportunity of stating some of the events which have culminated in the present satisfactory position of the company with regard to its contracts for machinery.

RELATIVE ADVANTAGES OF DIRECT AND ALTERNATING CURRENTS.

A few years ago it would have been considered necessary to devote a considerable amount of space to the discussion of the relative merits of direct and alternating currents. During the last two years, however, opinions have advanced so steadily in the direction of preferring the alternating current for the transfer of power to any considerable distance, that it is not necessary to give much time to this question. One of the chief difficulties in connection with using the direct current is that it is necessary for getting the best results, to connect a number of dynamos in series, and also to put the motors at the receiving end in series with each other. This involves the insulation of each dynamo and motor from the earth—a requirement which can in some cases be attained, but which in a general system of distribution is apt to be attended with difficulty, and perhaps with danger. The best case of the kind which has been put in practice is that of Genoa, and we gave it the most serious attention, but came to the conclusion that, for our purpose, it was undesirable.

The facility which the stationary transformers used with the alternating current give for varying the pressure according to the requirements of economy or safety, is one great feature in favour of the alternating current. The question was considered in all its bearings with the utmost care, and it was not until the month of May, 1893, that the board of directors passed the resolution to adopt the alternating current both for their distant transmission and also for the works nearer to the power house. It was proposed, indeed, by some manufacturers to distribute the current within a radius of a mile or two at 700 or 800 volts, and one firm proposed to do this by means of a direct current. Had this plan been accepted, we should have arrived at the surprising result that by using the continuous current at 700 volts within a mile or two, and high pressure alternating current for more distant places, it would have cost more to produce a horse-power per annum at Niagara Falls than at Buffalo.

The argument that seemed to me the most important in favour of using the direct current was, that motors for this purpose have been made in much larger quantities than alternators, and that it would be seldom necessary to build special types of machines to act as motors. This advantage seemed to be of great importance, until I realised the value of a low frequency used with the alternating current. So soon as we reduce the frequency low enough, we are able to alter a direct-current motor into a synchronising alternating motor, by the simple addition of a couple of rings placed on the commutator and electrically connected with opposite bars of the commutator, and a brush rubbing on each of these collecting rings. I also took into consideration the question of the possibility of storing up energy in storage batteries during the night time, when, of course, the demands on our plant would be least, and giving it off during the daytime; but at the present time the cost of the batteries would not repay work in this direction, and it would be cheaper to make another tunnel, with wheel pits, turbines, and all the paraphernalia required to generate current, than to go to the expense of putting down the large amount of lead which is required for these batteries. With the alternating current we have the choice of a considerable number of motors of different types. We have the synchronising motor, the series-wound motor with laminated field and commutator, the multi-phase motors which attracted so much attention at the Frankfort Exhibition of 1891, and a host of single-phase motors which have been developed by various inventors, but which have never been placed on the market because of the high frequency which has been prevalent, and with which they were not altogether satisfied. These motors become immediately available if we use a lower frequency. The generation of an alternating current also permits of the use of a commutator, or rectifier, with direct-current motors.

NUMBER OF PHASES.

Assuming now that it is generally agreed that the alternating current must be adopted, not only for the distant transmission, but also for the nearer work, the next point to consider is the number of phases—whether the current should be generated in a single phase, in two phases, or in three phases. The possibility, too, of using even a greater number of phases was also considered, but it did not seem to possess advantages.

As already stated, there are many motors which are suitable for use with a single phase at low frequency, and which start without assistance. In the workshops of nearly all the most able electricians which I have visited in the course of the last year or two, I have found such motors built upon different plans, and nearly all of them seemed to work fairly well, and promise to be very efficient at low frequency.

For all heavy work which is going on constantly without stopping the machinery, no motor could be more suitable than the synchronising alternator on a single phase, and its speed is as regular as that of the turbine which is developing the power. It seems, however, that if single-phase motors are going to be adopted, it would be best for the generator to have two phases, because, in this way, we get a larger output for the same size and price of machine; the circuits may be perfectly independent, and supply separate motors. Also, the two-phase system makes the rectification or commutation of the current more easy, to use it for street railways, electro-metallurgy, &c. Again, multi-phase motors have a great advantage that they have been considerably utilised already, and even in small sizes have a fairly good efficiency.

With regard to the relative merits of two and three phases, several claims that cannot be supported have been put forward in favour of the latter. First, it is claimed that the saving in the copper on the line is 25 per cent. over a one-phase system, and 25 or 13 per cent. over a two-phase system, according as four or three wires are used for the purpose. I investigated this matter carefully, and arrived at the conclusion that this was not the case, and that the three-phase system had no advantage in this respect over a two-phase system with three wires. Second, it is claimed that there is a greater simplicity of wiring with three phases than with two phases; but this advantage disappears when we remember that the two-phase system can be used with only three wires, although this is not a plan which I would recommend. Third, it is claimed that any pair of the three wires may be used for a distribution of lighting. This is not the case. A two-phase system, where the circuits are completely independent, is much more suitable for the purpose, and maintains the lights at a more constant electric pressure. Fourth, it is claimed that there is a smoother starting and rotating effort with the three-phase than with the two-phase system. This was originally claimed on theoretical reasons only by Dobrowolski, but everyone who has used the type of two or three-phase motors made by the Œrlikon Company, by C. E. L. Brown, and by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and others, is convinced that this advantage, which seems probable enough, is purely theoretical; it is not confirmed by actual practice, and, moreover, when the fact is known, the theoretical reason is pretty evident.

No other claims in favour of the three-phase system over the two-phase have ever, to my knowledge, been advanced; and, as shown above, a very full consideration of these claims does not tell in favour of the three-phase.

I will now point out what seemed to me great objections against the three phases, due to the fact that the three conductors are all inter-connected. First, it introduces trouble in maintaining the efficient working of the line, and in testing it, so that a higher type of electrician would be required to make these tests, and even he would have greater difficulty in finding the faults and correcting them. Secondly, when the three circuits are unequally loaded, the electric pressure varies considerably. These difficulties have been thoroughly appreciated by workers in this line. When an inter-connected set of circuits, such as the three-phase system employs is used, it is found that when the circuits are unequally loaded, there are great variations in the electric pressure, and the following tests were made at my request to illustrate this. The three circuits are called A, B, and C. The average electric pressure of the three branches at the terminals of the secondaries was maintained constant. A resistance tending to reduce the electric pressure at the lamps 5·3 per cent. was introduced into each branch. Both the primaries and the secondaries were connected as represented by the form of the letter Y. By varying the connections in different ways, some slight variations were possible; but this general fact remained—that when A is loaded and B and C are not loaded, the pressure of A is less than that of C, and that of C is less than that of B, and the difference may be 12 or 13 per cent.; and when A and B are loaded and C is not loaded, the pressure of A is less than that of B, and that of B is less than that of C. The variations here shown in the pressure of two equally loaded circuits is probably due to the armature reactions, and would be found in a two-phase system also; but the rest of the variation is due to the inter-connection of the three circuits, and is an obvious defect of the three-phase system. In order to get over this difficulty, the Œrlikon Company proposed to devote only one circuit to lighting

purposes, which shall be maintained at constant pressure, using the other two circuits for power purposes, where constancy of pressure is not so important. In some cases this would be a suitable method of working, but it was not considered satisfactory for the work at Niagara Falls. Having considered these points, the board of directors of the Cataract Construction Company, at their meeting in May, 1893, determined to reject the three-phase system, leaving the single-phase and the two-phase available.

Conditions.	Volts at terminals of lamp mains.				Difference between maximum and minimum volts.
	A.	B.	C.	Average.	
A, B, and C loaded (resistance out) ...	108·5	108·6	107·9	108·3	0·7
A, B, and C loaded (resistance in) ...	103·5	103·6	103·2	103·4	0·4
A loaded, B and C off	102·9	116·0	106·5	108·5	13·1
B loaded, A and C off	104·5	102·5	114·9	107·3	12·4
C loaded, A and B off	115·1	105·3	101·3	107·2	13·8
A, B, and C loaded, (resistance in) ...	103·0	103·4	102·5	103·9	0·9
A and B loaded, C off	98·9	107·8	111·1	105·9	12·2
A and C loaded, B off	101·2	108·0	98·1	102·4	9·9
B and C loaded, A off	110·5	98·0	105·8	104·8	12·5
A, B, and C loaded (resistance in) ...	103·7	103·0	103·0	103·5	0·7

FREQUENCY OF ALTERNATIONS.

I wish now to say some words on a question which has absorbed my most serious attention, especially since I have been acting for the Cataract Construction Company, and this relates to the frequency of the alternating current. In America a frequency has generally been adopted of 133 complete periods per second for lighting purposes. This was done with the object of reducing the cost of transformers, which were supplied to each separate house, and consequently were always of small size, and therefore expensive. The selection was also approved because American engineers working with alternating currents have generally put forward the view that parallel work is not desirable, and the fact that parallel working is more difficult at high frequency, which is one of the principal objections to high frequency, has not been seriously considered in America. In Europe the usual frequencies are from 70 to 100 periods per second, but a notable exception exists in the case of Messrs. Ganz and Co., of Buda Pesth, who have adopted 42 periods per second. Some years ago I unwittingly did Messrs. Ganz the injustice to say that I thought it probable that they had adopted this frequency because it suited their particular type of machinery and speed of running. I have it in writing from them, and I am thoroughly convinced of the truth of it, that their reason in adopting the frequency of 42 periods per second was that it is the lowest frequency that is available with arc lights so as not to produce any serious flickering, and their desire was to lower the frequency as far as practicable in order to ensure parallel working. Of course it is a matter of common knowledge that parallel working is assisted by lowering the frequency.

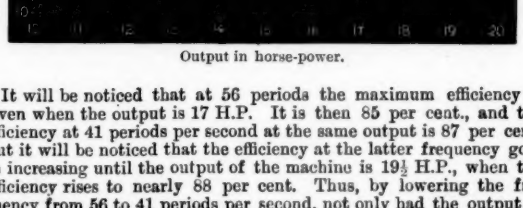
With the large units which will be employed in connection with the Niagara Falls scheme, the cost of the transformers is very much diminished; and this does not become so important a matter as it does when all the transformers are of small size—under 10 H.P., as is usual in electric lighting in America. Moreover, although with lower frequency the transformers must be increased in size, the increased cost is not in proportion to the lowering in frequency, because we can use a higher induction. Mr. Steinmetz has shown that the loss due to hysteresis varies as the induction raised to the power 1·6, and it is this loss which must be kept constant when we vary the frequency. I deduce from this law the fact that in any transformer, if the hysteresis loss is kept constant, its power of doing work varies in proportion to the frequency raised to the power 0·4 (but it is probably unwise to increase the induction so much as to saturate the iron). It follows that when we double the frequency we get out of the same transformer 132 units of work instead of 100. If the frequency were quadrupled we should get 174 units instead of 100. I have been informed by Mr. William Stanley, Jun., of Pittsfield, Mass., that without the use of theory, but simply working from his experience in manufacturing and testing transformers, he obtains almost identically the same law; and I have got independent practical testimony in the same direction from other manufacturers. It appears, then, that there can be no doubt that in lowering the frequency we are not proportionately increasing the cost; but at the same time it must be realised that the cost of transformers is to a certain extent increased by lowering the frequency. If the frequency be reduced to one-half, the cost is increased about 50 per cent. The lowest price which has been quoted for large transformers is $3·52 per H.P., at a frequency of 42 periods per second. In halving the frequency the extra cost would therefore only be $1·76 per H.P. It becomes, then, a matter of inquiry whether the benefits to be derived by lowering the frequency in such a proportion would compensate for the extra expenditure as indicated. I am thoroughly convinced that the gain is far in excess of this amount. I shall have occasion to discuss the superior efficiency of motors at low frequency; and in most types of motors I think it safe to say that in passing from 42 periods to 21 periods, or varying the frequency in that proportion, we have a gain of at least 3 per cent. in the efficiency of the motors. Neglecting altogether the increased value of the motors from this cause, there is 3 per cent. more power at our disposal, which, at only $10 per H.P. per annum, would amount to 30 cents per annum, or, capitalised at 5 per cent., represents an increased value of $6 per H.P. of the plant, against which we have the increased cost of transformers—only $1·76. It appears, then, pretty certain that, from a purely economical consideration of the question, a lower frequency than any which has hitherto been adopted is advantageous.

With regard to the lowest limits at which we can work, since our turbines have been designed to revolve at 250 revolutions per minute, a two-poled dynamo—if such could be satisfactorily constructed—would give a frequency of four and one-sixth periods per second, and none of the synchronising or polyphase motors employed at different factories could run at a higher speed than 250 revolutions. I am not sure that it is desirable that any motors should run at a higher speed than this, but in the few cases where this might be desirable the use of belts would be quite natural in order to give the higher speed. With a four-poled machine we would have a choice of speeds at 500 revolutions, 250 revolutions, and any sub-multiple of these speeds; for by increasing the number of poles in the motor the speed of the motor can be reduced as much as we please. With eight poles in the generator the maximum speed is 1,000 revolutions per minute, which is as high a speed as would generally be desired in connection with the factories supplied from Niagara Falls. This frequency is 16⅔ periods per second; and after considering the three points—namely, cost of transformers, speed of synchronising motors, and convenience in the design of the generators—I came to the conclusion that, so far as motive power was concerned, this is the frequency which would be the most favourable for use at Niagara Falls.

Another indirect advantage of using a low frequency is of a very practical nature, and lies in the fact that the ordinary continuous-current dynamos of any size that are made may be used as synchronising motors by means of rings attached to the commutator bars in the manner which has been above described. This method of altering and working a direct current motor so as to make it suitable for an alternating current of low frequency has long been known to electricians, but the attention of those who are not experts was forcibly directed to it by the machines shown by Mr. Schückert and others at the Frankfort Exhibition in 1891. Owing to this fact, it would be possible for any manufacturer connected with our supply station to procure a motor of low frequency of any moderate power he might require at a day's notice, and this is not true of any other alternating motor, nor is it true of a higher frequency.

But the most obvious advantage of low frequency is the improved efficiency of motors. I have arrived at this conclusion from my own observations, but I find it confirmed collaterally. With synchronising motors, of course, the fact has long been thoroughly established that the performance is very much improved by using low frequencies. Again, those who have used the motors with rotating field of the two-phase or three-phase type have all been obliged to reduce the frequency of the current to get the best results. In this connection I am pleased to be able to show a diagram giving some tests which were made for me of a three-phase motor at 41 complete periods per second, and at 56 periods per second.

Efficiency.



Output in horse-power.

It will be noticed that at 56 periods the maximum efficiency is given when the output is 17 H.P. It is then 85 per cent., and the efficiency at 41 periods per second at the same output is 87 per cent. But it will be noticed that the efficiency at the latter frequency goes on increasing until the output of the machine is 19½ H.P., when the efficiency rises to nearly 88 per cent. Thus, by lowering the frequency from 56 to 41 periods per second, not only had the output of the motor been increased 15 per cent., but the efficiency had also been increased 3 per cent. It is also found—which is a matter of the utmost importance—that in every self-starting alternating motor, whether multiphase or otherwise, the effort at starting is increased by lowering the frequency.

Again, I find that the ordinary direct-current motor, with a laminated field, works extremely well with low frequency; even without lamination of the field it works, though not well. I have consulted nearly every electrician of experience in this direction whom I have met during the last year or two, either in Europe or America, on this point, and they generally agree with me that the facilities of working motors of whatever kind are very much greater with a low frequency.

I wish to repeat that, from what I have seen in the workshops of all advanced electricians in the last year or two, I am confident that in the near future single-phase alternating current motors, self-starting on full load, will be largely used; and there is not the slightest doubt that all of these work far better with low frequencies. In fact, as Mr. Brush once said to me when I was discussing this matter with him, "Really, your best plan would be to lower the frequency so much that you get a direct current."

Whilst speaking of low frequency in relation to motors, I must say that I have much greater hopes of obtaining a good commutating device with a low frequency than with a high one; and I will also state that I have great hopes of important advantages coming to us from the invention of such a commutating appliance, which will enable us to furnish street railway companies, electro-metallurgical works, and other consumers with the direct current without the use of any heavy revolving machinery at the transforming station.

I am not sure that it ought not to be said that the greatest advantage of low frequency is in connection with the conductors used for transmission, and in the parts of the apparatus that require high insulation. When a high frequency is used, there are certain difficulties which are well known. The first of these has been strongly urged by Lord Kelvin, namely, that when using large conductors, an alternating current of high frequency tends to confine itself to the outside of the conductor, thus increasing the total resistance. Attention was first generally directed to this subject by the Presidential address of Prof. Hughes to this Institution. A second difficulty is that with high frequency the impedance of the line due to the magnetic field formed between the go and return wires may amount to a very sensible quantity. Then, again, with high frequency there is a greater tendency to discharge from an electrified conductor into the air. This means that the insulating of a bare conductor is more difficult with a high than with a low frequency. Lodge and others have made this very manifest with exceptionally high frequencies, but the truth of the statement is well known by those who have experimented even with lower frequencies. Another trouble is that, whenever it is necessary to use solid insulation, a current of high frequency has a greater tendency to injure the insulation. Mr. Tesla has shown and explained so clearly the rapid deterioration of solid insulation by currents of enormously high frequency, that we cannot fail to see that advantage is gained by using currents of low frequency. Another very important fact is that with low frequency we are less troubled by the capacity of cables, and we have less loss of static charge accompanied by heating of the insulation. Again, the serious troubles which have been encountered at Deptford and elsewhere owing to abnormal rises of electric pressure in the mains above the pressure generated by the dynamos, due to the resonant effect produced by the capacity of the cable and the self-induction of the circuit, may be reduced as much as we please by sufficiently lowering the frequency. All these facts are the explanation of what has been thoroughly established in actual practice, namely, that there are difficulties on the line when using high frequencies which tend to loss of power and to destruction of the insulation, and that these difficulties are largely mitigated, if not entirely obviated, by reduction of the frequency. It must also be remembered that, if we reach a frequency as low as 16 periods per second, any induction in neighbouring telephone circuits is utterly inappreciable by the ear. Finally, all eddy currents diminish as the square of the frequency. Having now stated, as clearly as I can, what seemed to me the principal advantages of low frequency, I will place on the other side the disadvantages.

Besides the increased cost of transformers, there is one fact which is apt, at first sight, to impress one as almost fatal to the employment of very low frequency, but which further consideration shows to be of little moment in the case of Niagara Falls; that is, that a low frequency is not suitable for electric lighting directly. But it must be remembered that it is decidedly preferable to use a direct current for arc lamps, and, in fact, in the present position of the art in America, it would be almost a necessity. Hence the natural method of arc lighting would be to use the alternating current by means of a motor to drive the well-known arc lighting machines. In the course of the work at Niagara, the first work in connection with arc lighting which will be set up is the lighting of Buffalo. At present this is done by means of steam engines, developing about 3,000 H.P., and driving arc lighting machines of the Brush, Thomson-Houston, and Wood types. There cannot be a doubt that, financially and practically, the best way of converting this station to enable them to use the power from Niagara Falls is to put in alternating motors in the place of the steam engines; and this will be the case in most of the towns which will be supplied with power from Niagara Falls.

It will be well at this point to say something about the frequency which is required to prevent the arc and incandescent lamps from flickering. I have made a number of experiments on these points, and my conclusions are as follows:—A 16 candle-power 50-volt incandescent lamp shows a flickering almost up to 25 periods per second, at which frequency the flickering ceases when at its normal brightness; but if pushed to an excess of incandescence, the flickering was just perceptible up to 27 or 28 periods. I believe that a 100-volt 16 candle-power lamp shows a perceptible flicker up to 28 periods; but I may mention that this flicker is not nearly so serious or perceptible as that which frequently arises from the employment of certain types of engines, especially single-acting high-speed engines, when sufficient fly-wheel momentum is not provided. As a case in point, I would mention the lighting in the Holland House, one of the best hotels in New York, where, to an experienced eye, the flicker of the lights in the large dining room from this cause is very objectionable. The thinner the filament, the more liability is there to such a flickering. I have lately examined the thick filament lamps to which the name of "Bernstein" lamps has been given, which consume 6 to 10 ampères at low voltage. It takes so long a time for the incandescence to die out when the current is stopped, that I have little doubt about their being able to work without any perceptible flickering at so low a frequency as even 16 periods per second. I have also made some experiments of a similar nature on arc lamps at low frequencies. At 37½ periods per second there was very bad flickering, and this was most noticeable when looking at a piece of white paper illuminated by the naked light, or when looking at an opal shade put on the lamp. At 40 periods it was still bad. Neither at this speed, nor at the previous one, was there any serious noise, but at 40 periods the noise could be perceived by putting a glass globe over the lamp resting on the metal framework directly. At 41·7 periods there was just enough flickering to be objectionable; at 45 periods it was just possible to notice it on a printed page held close to the lamp, but it was not visible when reading at a distance of 10 feet. At 50 periods the only means of detecting anything of the sort was by looking directly at the arc; nothing was seen when reading a book either with the opal shade on or off. At this frequency the noise became much more perceptible, especially with a long arc about one-eighth of an inch. On reducing the length of the arc to one-sixteenth of an inch the noise was much less. In all these experiments the consumption of energy was at the rate of 26 volts and 14·2 ampères at the lamp terminals. The best cored carbons of Siemens & Halske were used.

An objection has been raised to the use of low frequency owing to the fact that a periodical twisting strain is given to the shaft of the dynamo, but this objection disappears almost entirely when we are dealing with a machine generating two phases.

It follows, therefore, that for arc and incandescent lighting at a very low frequency it becomes necessary to use alternating-current motor-generators, or else to use something of the character of a commutating machine to convert into continuous currents. Such machines as those exhibited by Schückert at Frankfort in 1891 are useful up to a certain extent, but they are expensive, and comparatively inefficient, as their only function is to commutate the current—an operation which ought not to involve any significant loss. At the present moment a good commutator for the alternating current is not upon the market, but the matter is of such prime importance that I feel confident that much will be done in this direction. In fact, I have seen enough with my own eyes to have no fear about our being able to generate continuous current from the two-phase alternating current without serious loss, and with very inexpensive machinery. If, however, the object of our work was mainly, or even to a considerable extent, to provide the means of lighting towns by arc and incandescent lamps, I should have hesitated to recommend a reduction in frequency below 42 periods per second, such as is used by Ganz & Co., and which is operated so successfully at Rome and Tivoli, and at a very large number of other places on the Continent. The officers of the company and myself considered this matter most carefully, and, looking at the purposes for which our machinery is being set up, we felt sure that the proportion of electricity which would be used for lighting purposes would not be large, and that we must look upon our whole plant as a power producing and distributing plant, and that our object must be to distribute power in the most efficient and economical manner. This being the case, we agreed that it was desirable to lower the frequency so far as the mechanical conditions of the problem would allow. The lowest frequency which had been offered to us by the manufacturers was a very beautiful design of a machine at a frequency of 20 periods per second. This machine had admirable qualities, but was in some points not exactly adapted to the requirements of the situation, as developed by the selection of a special design for the turbine.

I have myself made several trials of designs at very low frequencies, even as low as eight and one-third periods per second, and for this frequency I prepared drawings of a machine which, though by no means perfect, shows a possibility of being worked into a sound machine of good mechanical construction; but further considerations led me entirely to modify the design of the machine, and eventually I arrived at the conclusion that, both from the point of view of design of the dynamo, and also for suitability of applying the current, 16 periods per second was probably as good as could be obtained. The manufacturers to whom the contract has been given were anxious to use a lower induction in the iron of the machine than that which I would have preferred, and this rendered the machine of 16 periods per second heavier than could be supported by the hydraulic piston which supports the whole weight of the turbine, vertical shaft, and revolving part of the dynamo. Consequently we have made a compromise, and are going to build our first three dynamos with a frequency of 25 periods per second. In concluding my remarks upon low frequency, I must again repeat that, from a purely practical and commercial point of view, one of the great advantages lies in the fact that for any special purpose for which a motor is required any ordinary direct current motor may be altered so as to act as a synchronising alternating motor at a very small expenditure of time and money.

ELECTROMOTIVE FORCE.

The question of selecting a suitable electric pressure for working to Buffalo, and also for local purposes, is of some importance. Generally speaking, it is desirable to use as high an electric pressure on the line as is consistent with safe and continuous working, as this effects a great saving in the amount of copper used on the line. In the first report, founded on insufficient data, which I wrote more than three years ago for the Cataract Construction Company, I recommended that 2,000 volts should be used in the neighbourhood, and that the pressure should be raised by means of transformers for the more distant transmission. But the greater portion of our work in the immediate future will have the character of distant transmission. In most of the tenders which were submitted to us the cost of transformers was almost as much as that of dynamos, in some it was more, so that the use of a step-up transformer for distant transmission meant almost double the cost of generating the current. I hold the view that a pressure of even 20,000 volts can be generated as safely in the dynamo machine itself as in the transformers, and that if we used 20,000 volts for the local work as well as for Buffalo, we should not be incurring the additional expense and losses of a step-up transformer, while we should be saving enormously in the cost of copper. Unfortunately, American manufacturers have never supplied alternating current dynamos at a higher pressure than 2,000 volts, and they are not practically acquainted with the experiences which have been gained in Europe at extra high pressure. Most of the manufacturers declared their inability positively under any conditions to go above 2,500 volts, although some of their engineers were willing to go as far as 5,000 volts. This, however, would have been no material gain to us; and the consequence is that, to meet the views of the manufacturers in our preliminary work—that is to say, in the construction of the first three dynamos for our power house—these will be only of such electrical pressure as they are accustomed to deal with. We shall therefore be using dynamos generating cur-

rent at 2,000 volts, and employing step-up transformers for the extra high pressure. This may possibly render it desirable in our first work not to use the extra high pressure for local purposes. Besides the actual cost of the conductors, a very serious matter arises when we are dealing with the large currents due to comparatively low electric pressure. I refer to the large quantity of copper which has to be put into the conductors. Working at 2,000 volts, each phase of each of our generators will give nearly 1,000 ampères, without considering the effects of retardation of phase, which will increase the current by quite a perceptible amount. So that, to put in the most economical section, will require 3 square inches for each conductor or 12 square inches of copper for each 5,000 H.P. dynamo, or 36 square inches section of copper for the 15,000 H.P. which is now being supplied. When we remember that even with low frequency the question of skin resistance comes into play when the conductors have a large diameter, it is obvious that we are introducing serious troubles, and if a subway were to be made to carry these conductors it would require to be of very great dimensions. For these reasons I am still anxious to see the extra high pressure used even for the factories within a distance of a mile. The uniformity of the system would undoubtedly be of great benefit to us if we could generate the whole current for all purposes at the same extra high electric pressure, but as I have stated, we were obliged to content ourselves with a somewhat less perfect arrangement than would be adopted if we were dealing with the utilisation of a waterfall in Europe.

I wish to lay stress on the importance which I have considered to lie in the fact of having a perfectly uniform system with interchangeable dynamos. Many engineers to whom I have talked, have suggested the use of special dynamos at different pressures for special purposes; but if we had a special dynamo for arc lighting, and another for incandescent lighting, a third for street railways, another for electro-deposition, and so on, the possibility of interchanging dynamos would disappear, and the whole system would be much more complicated to work.

I wish now to make a few remarks about the insulation which it has been customary to put upon dynamos and transformers which were to be used with high electric pressure. Many persons who have not given sufficient attention to the subject seem to be inclined to believe that there is something mysterious about the tendency of electricity in a dynamo or transformer to break through the insulation, and which prevents them from being subject to the ordinary laws of electricity. Thus, when building a dynamo for 2,000 volts, a thickness of insulation is given which would stand a test of more than 100,000 volts without breaking down, and it has been found from the ordinary methods of using the plant that if something of this sort is not done, the insulation will break down. I wish to point out that the reason for this lies in the fact, not that the insulation breaks down with 2,000 volts, but that in a 2,000-volt system as generally used, electromotive forces are occasionally generated amounting to 100,000 volts or more. These abnormal rises in electric pressure are chiefly due to the resonant effect, which has received so much attention of late years, and may be caused by the sudden breaking of the circuit of the dynamo. If these causes of excess be avoided, the electric pressure will never rise above the working pressure, and the insulation will never break down, even though its thickness be only little more than sufficient to stand a test at the working pressure. Dr. Fleming has shown us how to kill the resonant effect, and such a phenomenon never appears now at Deptford. This trouble may also be avoided by having as little capacity on the line as possible, especially when combined with low frequency. As to the cause of trouble mentioned above, I hold that it is a piece of culpable ignorance, ruinous to the machinery, if anyone should ever, on a large power circuit with alternating current, suddenly break the circuit while current is passing. This practice is quite unnecessary, and has given rise to a large proportion of the breakdowns of alternating current machinery.

PARALLEL WORKING.

Engineers in America have had no experience in actual commercial conditions of parallel working with alternators. This is partly because the machines which have been made in that country do not work so well as some others in parallel. In the case of the transmission from Niagara Falls, my opinion is that parallel working will give the best results. If this arrangement were not adopted, it is obvious that when the dynamos are loaded up as much as possible, they could never be all fully loaded. It is also quite obvious that if our conductors are to be carried through subways, the space required becomes quite excessive, unless we adopt parallel working. The complete success of parallel working between Tivoli and Rome left no doubt as to the feasibility, besides the desirability, of adopting parallel working. The reduction in frequency which we have made assists very considerably in this result, and it says much for the American manufacturer who has received the contract that, although parallel working with multiphase machines has not been adopted in the past, he is ready to guarantee the performance in this respect of the machines which are to be built for us.

The rules which govern the construction of machines which shall work well in parallel are not very clearly understood. The only fact which has been perfectly established in practice, is that the lower the frequency, the more efficient and sure is the parallel working. It certainly depends to some extent upon the amount of self-induction, and the amount of mechanical momentum in the machines. It is also certain that if the self-induction of the machines is too high, they will not work well in parallel. Of all machines which have been constructed, those which work the best in parallel appear to be those of Ganz & Co., Mordey, and Elwell-Parker, but there are many others which do extremely well. It is, at present, not possible to state exactly the conditions which are necessary, but I may say that, generally, a machine with a stiff magnetic field works better than one where the iron is far below magnetic saturation. In judging whether a machine of a particular type will or will not work in parallel, I think one must be generally guided largely by one's own personal experience in the matter, combined with a knowledge of the effects of self-induction, mechanical momentum, and magnetic saturation as deduced from theoretical considerations. I do not think that anyone who knows anything of the working of the Tivoli-Rome plant would for a moment hesitate in saying that on a large and important station like that at Niagara Falls, parallel working is essential; and this is the opinion of Prof. Mengarini, who has so ably directed the works at Rome.

MOTORS.

Under this section it may be as well to discuss some of the different purposes for which the electric current will be required. With regard to arc and incandescent lighting, if the frequency be high enough, the current can be used directly for this purpose; although most people would prefer that, in the case of arc lighting, the current should be commutated or converted in some manner so as to give a continuous current. That this is unnecessary, however, is amply proved by the perfect success of the arc lighting by alternating currents in Rome, and many other large cities, especially those which have been established by Messrs. Ganz & Co. At the present time one of the largest applications of electricity in the United States is for street railways, which require a continuous current. Another similar purpose which we shall have to consider is the application to canal boats, since it is intended to work the Erie Canal by electricity. This canal starts from the Niagara River, and reaches the Hudson River at Albany, 350 miles distant. For these purposes some sort of commutator or motor transformer will be desirable. Some of the first work which will be done is the supply of much direct current at 150 volts for the production of aluminium. This also requires the continuous current, and similar means must be used for obtaining it. Among the large class of mills which will be established at Niagara Falls, one of the most important kind is wood-pulp mills, one of which is already working on our land, and will be the first to receive water-power from our canal. This type of mill uses many thousands of horse-power, and is worked continuously day and night. In this feature it resembles, probably, a large number of the mills which will take advantage of the cheap power at Niagara Falls. Such mills are working continuously day and night, and do not require to be ever stopped or reversed. This is an important class of work in our case, because current can be supplied to such mills by means of synchronising alternators whose efficiency is extremely high, and this may perhaps be done in some cases without transformers. We require also to consider the case of small motors for use in shops, and for elevators, cranes, and a large number of other purposes. In this type of motor frequent stoppings and reversals are necessary. Hitherto direct current motors have generally been employed for this latter purpose, but the rotating phase induction motors are distinctly suitable, and when these have been fully developed they will probably be largely used for this purpose. The commutated current is a thing which is sure to be in common use before long, and although our arrangements at Niagara Falls are perfectly complete without a machine for this purpose, still its employment has been considered by us, and the probability of its future use has influenced our judgment in some points. There are so many purposes for which the direct current is most convenient, that people would generally accept it for transmission if it were capable of being economically transformed up and down to different pressures. The direct current dynamo is really an alternating dynamo with a commutator placed upon it. If the commutator, instead of being placed there, be placed in the neighbourhood of the motor, we obtain most of the advantages both of the continuous and of the alternating current. This is one of the advantages of having two phases generated by the dynamo, because it is much easier to rectify a two-phase current than a single-phase current. In addition to the motors above specified, there are a large number of single-phase motors which start with a powerful torque which have been invented by different electricians, but which are not yet put upon the market. There are also machines with commutators like a direct-current dynamo with laminated field. These all become very efficient and useful when the frequency of alternations is sufficiently diminished.

LINE CONSTRUCTION.

A great deal of attention has been given to the different methods by which current can be conveyed to the points of consumption, whether on our own property or at Buffalo, or even further. Naturally the pole line was first dealt with, in which the poles might be constructed of either wood or iron. This is the cheapest type of construction, and has some advantages, but we must consider the climatic conditions in the neighbourhood of Niagara Falls. We are subject there to severe thunderstorms, and troubles from lightning have already been serious in several parts of the United States in connection with electrical machinery. Snow and frost are very severe, and sleet forming upon the wires and insulators may cause a great amount of trouble. There are also at times very violent gales sweeping from over Lake Erie. All these difficulties can be counteracted to some extent, but it is nearly certain that with overhead construction occasions would arise when the continuity of operations would be interrupted, and this would be a very serious matter. The next system to be considered in order of cost would be underground cables, but I am strongly opposed to the adoption of these for any considerable length. It is true we are able to deal with their capacity so as to reduce its injurious effects, but surely the best plan of all is to abolish the capacity itself as far as possible. The most satisfactory method of proceeding is to build a subway of sufficient size to enable a person to walk along it and to carry bare copper conductors in it, but this is a matter of considerable expense. I am glad, however, to be able to inform you that the officers of the company resolved last summer that a subway such as I have described should

be constructed from the power house up to the Pittsburgh Reduction Company's works, where aluminium is to be produced, a distance of 2,500 feet.

With regard to the electric pressure that is to be used for distant transmission, this will undoubtedly advance with experience. Some manufacturers in Europe who tendered for the work proposed to adopt 25,000 volts, which is a step in the direction of Lord Kelvin's suggestion of 80,000 volts; but we have considered that at present 20,000 volts is not likely to be exceeded by us, and we may work at a lower pressure at the commencement. When it is remembered that the Deptford machines have one terminal connected with the earth, and are working satisfactorily at 10,000 volts, and when it is noticed that, in consequence, our work would be under exactly the same conditions as regards insulation when working at 20,000 volts, it is easy to see that we are not risking anything experimental in our first work.

With regard to the size of conductors, I worked out the economical size at different current densities for the whole distance. In doing this I took the following data:—I took the cost of copper at 12½ cents per lb., and the annual charge on this cost at 5 per cent. I then computed the power loss in the line, and the amount of power which was left available for delivery. I took the value of this power at the distant end of the line as being $15 per H.P. This is something more than what it costs us to produce it, but when the power available from our tunnel is nearly all consumed, this quantity will have to be increased. It must also be remembered that I have not allowed for the increased size of the conductors required by the retardation of phase, which is an unknown quantity. Still, it will be seen that from these considerations we may be able to work economically at a slightly higher current density than is obtained from this investigation. From this work it appears that the most economical density to work at is 350 ampères per square inch. If this density is used, the fall in volts between Niagara Falls and the northern boundary of Buffalo is only 3½ per cent.—a matter which makes regulation extremely easy.

With regard to the efficiency of the system, it is remarkable how high the efficiency of the dynamos comes out when we are dealing with the large units of 5,000 H.P. There can be little doubt that the efficiency, electrical and mechanical, of our dynamos may reach at least 98 per cent. Taking off 3½ per cent. for losses on the line, we would have 94½ per cent. delivered electrically at Buffalo if no transformers were required to raise the electric pressure to the full 20,000 volts. In cases at Buffalo where the power consumed is very large, the motor can be constructed on the same principles as the dynamo; and if in this case it be ever possible to work at the full pressure without a transformer, it is obvious that the total efficiency of the system—that is, the power delivered by the motor to the shaft of the machinery, divided by the power delivered by the shaft of the turbines to the dynamo—will be certainly over 90 per cent. As a matter of fact, if we were to use a higher density of current, and were to use step-up transformers at Niagara Falls and step-down transformers at the northern boundary of Buffalo, and other step-down transformers in the town of Buffalo itself, and were to use motors of small power, and consequently less efficiency—in this case the total efficiency of the plant might be reduced to 80 per cent., or even lower.

I have given these figures, not as indicating precisely the lines on which we have determined to work at Buffalo, but because the present paper is intended to embrace the subject of the general distribution of power, and I thought it desirable to lay before you certain facts in this connection in a definite form.

DESCRIPTION OF MACHINERY TO BE USED.

Under this heading I shall deal chiefly with the type of dynamo which has been finally decided upon. It will suffice to say of the turbines that they are each of 5,000 H.P., that they revolve at 250 revolutions per minute, and were designed by Messrs. Faesch and Piccard, of Geneva. All the principal parts of this machinery were constructed by the I. P. Morris Company, of Philadelphia, but the governors of the turbines are of Swiss manufacture, and part of the steel fittings were constructed in France.

With regard to the dynamo, the Cataract Construction Company at first invited many different manufacturers in Europe and America to submit plans. The number of these that were submitted altogether amounts to 24, some of the manufacturers having taken a great deal of trouble to submit a series of designs, in order to be able to meet different requirements. Many of these designs were extremely good; but it was determined, after estimating the increased cost of using the European designs, owing to the high tariff in America, and owing to transport, to have the machines manufactured in America. Among the designs from American manufacturers there were none which fulfilled all the requirements of the case, and eventually the Cataract Construction Company decided to get out their own designs and to submit them to the American manufacturers for tender. I had been for some time previously engaged in working out a design which I am confident none of the manufacturers who had sent in designs could say was in any way borrowed from their ideas. We had received suggestions of an external armature with internal revolving fields, and also of external fixed fields and internal revolving armature. We naturally had a preference for a dynamo with a fixed armature, because the coils can be more securely wound, and are not subjected to the mechanical stresses induced by centrifugal force. But all the designs with revolving fields which had been submitted to us contained a weak feature: the field coils were held in by pole faces secured by bolts or keys to the poles, and this seemed an element of weakness when we considered the enormous centrifugal forces to which the machinery would be subjected. At the same time, the turbine makers had insisted upon having a certain momentum, or fly-wheel effect, which was not given by the revolving parts of any of the dynamos submitted to us, and it was found that if any one of these had been accepted it would have been necessary to add to the design a fly-wheel of large dimensions. Centrifugal force was one of the most important matters to be considered, because at 250 revolutions per minute this force assumes considerable magnitude in the large masses with which we had to deal. Moreover, in all the designs which had been submitted, the magnetic pull between the poles and the iron of the armature assisted the centrifugal force. The principal feature of the design upon which I was working consisted in having the armature fixed, and inside the machines, with the fields revolving outside; the fields being formed of a ring of iron with the poles projecting radially inwards. One advantage is that we are able to get the full fly-wheel effect that was required by the turbine makers. This requirement was that in the revolving part the sum of the weight in pounds of each part, multiplied by the square of its velocity in feet per second, should equal 1,100,000,000. The design also gives an extremely good mechanical construction for the revolving parts. The iron ring which forms the yoke of the fields serves as a support to hold in the pole pieces and the exciting coils, and no part is held in against centrifugal force by bolts or keys. Moreover, the magnetic pull between the fields and the armature acts in opposition to, and does not assist, the centrifugal force. The armature is fixed, and a large space is available inside it for the workmen to attend to the bearings, and to reach any part of the armature. It is obviously possible to insulate the armature coils for any electric pressure. With a large machine of this kind the space occupied by insulation has not the same importance in reducing the output of the machine as is the case with machines constructed in the past. In fact, the armature coils can be wound with the same insulating properties as a transformer, and hence the necessity for using a step-up transformer can be avoided.

Starting with this general principle, I first got out designs of a machine at 33 periods per second, in order that I might compare the general appearance of such a machine with those of other types. The next point was to design a machine of as low a frequency as was possible under the limiting conditions as to weight. The revolving parts of the turbine and dynamo, and the shaft connecting them, are supported by a hydraulic piston, and it was the desire of the Cataract Construction Company not to use a thrust bearing of any kind to support the weight, although there is a thrust bearing at the top of the shaft, which simply acts to retain the apparatus in a fixed position in a vertical direction. Owing to this decision, it was necessary to limit the weight of the revolving parts of the dynamo to 80,000 lbs. In getting out the design for this machine it was desirable to select such a form of winding as past experience led one to believe would be most efficient for parallel working, and I judge from past experience that this is best attained by having the number of coils per pole very small. The 33-period machine which is shown in the drawings has only been sketched out with a view of getting at the general dimensions of the machine. It is not suitable for our special purpose, because it is essential that, without taking the dynamo altogether to pieces, we should be able to lift up through the centre of the dynamo any parts of the turbine shaft which may require repair.

It will be seen that from the necessities of the case at Niagara Falls the dynamo which was required differed in some respects from what would be necessary in many other cases, but it is equally obvious that in any case of so large a transmission of power the conditions must be thoroughly considered beforehand, and the dynamo specially designed for the purpose. At the meeting of the board of directors of the company in May, 1893, I was instructed, with Dr. Sellers, to get out plans for an alternator of the type which I have described.

I am not able to lay before you now plans of the machine as it has been finally adjusted by conference between ourselves and the manufacturers. In the plan which we prepared, the frequency was 16⅔ periods per second, there being eight poles. The armature coils were so wound that they might be connected to give either 2,500, 5,000, 10,000, or 20,000 volts, and the coils were limited in number so as to give the best assurance of good parallel working. For various reasons we decided eventually to raise the frequency to 25, and to lower the volts to 2,000, without the means of connecting the coils to give a higher pressure; and instead of winding the armature on the conductors in a limited number of coils, to adopt the methods more commonly used in some of the large types of generators. But since in any future work which is done the dynamo will be required to be modified for the special purpose, a description of the machine—of which I am able to show you the drawings—is sufficiently representative of the type of machine for our purpose.

GENERAL DESCRIPTION OF A 5,000-H.P. ALTERNATOR.

On the bed-plate a vertical cylinder is bolted, with projections to support the fixed armature and the bearings of the revolving part. The armature coils are wound independently, and can be removed and changed. They are fixed in slots in the fixed armature. They are encased in an oil-tight casing, through which oil can be circulated. The field magnet is external to the armature, and has the poles pointing radially inwards. It consists preferably of forged steel, supported by a spider with eight arms, which may be of steel, with a covering of thin sheet metal, on which cups are provided for forcing air into the interior of the machine. The pole pieces are bolted on to the steel rim. The field coils are of copper strip, two coils being wound upon each pole, with a space between them for air circulation. The exciting current is applied by rings of tempered copper on the spider, having fixed brushes rubbing on them. The hub of the spider is firmly fixed to the upper end of the shaft. The spider supports the heavy rim by 16 studs and nuts. The shaft is supported by two bearings, each of which has four radial arms, which are bolted to four corresponding projections on the cast-iron cylinder. This cast-iron cylinder is bolted to the bed-plate, and adjusted thereon by wedges. Besides having on it the projections for carrying the bearings on its inner side, it has on its outer periphery a series of vertical ribs, against which the stampings, or sheets of iron forming the armature, rest.

It also supports the lower end plate on which the armature is built up, and the armature is keyed to it by a single key. The armature is wound drum fashion—that is, all on the outside. This enables the coils to be wound independently, and laid in their place, and also to be easily replaced in case of accident. In order to do this satisfactorily, the slots for each coil in the iron are cut, not radially, but parallel to each other. Each coil is encased in insulating material, which forms a tube through which oil may flow as in a transformer, but may be forced, in which case its circulation is maintained by a pump. Round the base of the machine there are two oil pipes, one being the inlet, the other the outlet. The inlet pipe is connected with a reservoir of oil in the power house. The outlet pipe leads by another pipe to cooling arrangements in running water, from which the oil is pumped to the reservoir. From the inlet pipe 16 brass tubes are led to the junction boxes at the bottom of the 16 coils; the 16 other brass tubes are led from the junction boxes at the top of the coils through the interior of the fixed armature, and bent over the foundation plate, and so connected to the outlet pipe which surrounds the bed-plate. The bed-plate is a single iron casting, and in order to enable it to be transported over the railways, it was necessary to limit its diameter as shown in a supplementary drawing, which shows the improved oiling arrangements, which were worked out by my chief draughtsman at Niagara Falls, Mr. Baumann. The armature is built up of thin sheet iron, with ventilating spaces, as shown on the drawing. The bolts which hold the armature together are eight in number, to be made of nickel steel, a metal which has the great advantage of being non-magnetic, and of very high electrical resistance and great mechanical strength. The amount of nickel is 25 per cent.

There are 16 armature coils, eight being of one kind, called "short" coils, and eight of another kind, called "long" coils, the length of wire on each coil being the same. The short coils are bent over at the end plate, and the long coils are wound in one plane, and enclose the short coils. I find that if we are to have a very stiff field, with first-class quality of iron in the fields, each coil would consist of 72 turns of pure copper wire, No. 0 of the Brown & Sharpe gauge, which gives a very low density of current, and reduces the heating. In fact, it has been my view that in designing the machines for so great and permanent a work, every effort should be made to reduce the rise in temperature, even to far below what has ever been done in the past. The unequal expansions and contractions of materials in a machine of this kind are very injurious to its permanence, and affect the insulating material seriously. The layers of wire in the coils are separated by mica. Each coil, when wound, has strips of insulating material laid spirally round it, so that oil may circulate freely in the intervals, and the whole is encased in a casing of strong insulating material. The material which I prefer for this purpose is certainly Woodite, an eighth of an inch of which will not break down with 30,000 volts, and which is not acted upon by oil even at high temperatures. I have a record of tests with oil which are conclusive on this point. It is quite the best material I have seen for the purpose, though costly, and being a secret process, it may be difficult to ensure uniformity.

The frames of the bearings are of cast-iron, with four radial arms, which rest upon four projections cast on the vertical cylinder, and are bolted to them. By this means, when the field magnet with the shaft have been lifted out of place, the bearings can be twisted through an angle of 45° in a horizontal plane and then raised out of place, leaving a space 5 feet in diameter, through which portions of the turbine shaft can be raised for repair. The bearings are oiled at the centre by oil forced under pressure through a pipe. The oil is then distributed over the bearings by spiral grooves. A spiral groove is also cut in the hub of the frame, with a pipe at each end to admit of water circulation to cool the bushing. At two opposite sides of each bearing the bushing is made thin, and a rod of bismuth is soldered thereto; so that if the bushing is heated a thermo-electric current shall be created, which, by means of a relay, can ring a bell in the power house. When this occurs, water can be immediately admitted to cool the bearings, and the attention of the workmen is drawn to the necessity of an examination.

One of the parts which required most consideration was the material of which the spider supporting the field magnets should be constructed. The best plan is to make it of steel, for the sake of lightness, and to cover it with a copper covering, which might, I think, be spun; or, perhaps better, electro-deposited nickel might be used.

Between the pole pieces the space is filled up with a screen or plate of metal so as to direct the air ventilation only upon the parts which most require cooling.

The methods finally selected for oil circulation are shown in a separate drawing.

It will be obvious from this design, considering that the speed of revolution is 250 per minute, that great care has to be devoted to the balancing of the revolving parts; everything has to be calculated not only for a speed of 250 revolutions, but for double that amount, which is the maximum speed at which the turbines could possibly run—at which speed they might run through a breakdown of the governor, although this is an accident almost impossible to occur. Each of the revolving parts will of course be balanced individually, and I have suggested a plan for the final balancing which seems likely to be effective. A temporary bushing would be put in the bearings, of India-rubber lined by a thin metal tube. The dynamo would then be rotated slowly and the balance adjusted in the usual way. The speed of revolution would be gradually increased—a new adjustment being made at each speed—until a speed of 500 revolutions a minute is attained, and when an adjustment has been made at this speed it is pretty sure that the balance at 250 revolutions per minute will be very perfect, and the mechanical friction reduced to a minimum.

As stated before, the oiling arrangements have been introduced not only to ensure higher insulation and to preserve the insulating material, but also to lower the temperature as much as is possible, because every step we take in the reduction of temperature is an advance. These oiling arrangements may perhaps be adopted in the future, but at present we are not making use of them in the machines which are in process of construction. When we have had experience with these we may in future adopt the oiling arrangements; and as there is likely to be a great development in the direction of electric transmission of power in connection with the utilisation of water power in many parts of the world, it has seemed well to me to put before you these details, so that they may be considered in other cases that may arise.

At a meeting of the board of directors in New York lately it was resolved, on the recommendation of the consulting engineers of the company, that the contract for two or three alternators, each of 5,000 H.P., should be assigned to the Westinghouse Electric and Manufacturing Company, of Pittsburgh. I would wish to state how much we owe to Mr. Westinghouse, and to his chief engineer, Mr. Schmid, for the zeal with which they have taken this matter up, and their desire to meet our views and to secure for us machines of which they felt they could guarantee the satisfactory performance.

Before leaving the subject of the dynamo, I would wish to point out that it has been designed for special circumstances in connection with the Cataract Construction Company's work. If a dynamo of the same type were being constructed for another place, it is certain that modifications would have to be introduced. I particularly draw attention to the fact that some trouble in getting out a good mechanical design arose from the necessity which existed of being able to provide a clear space of about 5 feet diameter in the middle of the machine without taking the whole machine to pieces, the object of this being to enable us to lift up portions of the turbine shaft which it might be required to put into repair. In any case where the long shaft existing in our case is not required, the design of the dynamo is much simplified, and would more nearly approximate to the first design of which a drawing is shown, but arranged for 33 periods a second.

If the present paper were intended to relate solely to the subject of the utilisation of power at Niagara Falls, I would be content with describing what has actually been done, but I foresee that there is going to be a great development in utilisation of water power, and its electrical transmission. I am therefore inclined to say a few words on some other details which we have been carefully considering, but about which no definite decision has been arrived at.

With regard to the exciting current, the best plan available at this moment is to use one of the machines which are generally known as the Schückert machines, for converting the alternating into a continuous current, transformers being inserted in order to lower the pressure. In order that the exciting current may increase with the load, it would be well to make these transformers of special construction, each having two primaries and one secondary. One of the primary coils would be in series with the main circuit, and the other in shunt. I would furthermore make these transformers sufficiently large to deal with all the dynamos which are in the central station, and I would subdivide the secondary coil into sections, to enable us to cut out a section of the transformer when we cut out one of the dynamos. When we wish to cut out a dynamo, a switch would be worked which would at the same time short-circuit the field coils of that dynamo and also cut out one section of the secondary of the transformer which is supplying the exciting current to all the dynamos. This plan allows the fields of all the alternators to be put in series—a desirable arrangement for parallel working. A resistance may of course be put in circuit with the fields of the alternators for regulation.

I presume it will be taken for granted that in any large work of this sort the primary circuit should never be broken when in action. For my part, I hold that this should be the case even in smaller stations.

An important feature for putting the dynamos in parallel, and for removing a dynamo, is an artificial load. It is desirable that this artificial load should consist partly of a resistance and partly of self-induction. It is only by this means that the dynamo which is going to be put in circuit can be brought to exactly the same condition as those which are working, both as regards volts and ampères. It may be well to describe the operations which take place when a dynamo is switched in parallel with the others. First, connection is made between the armature and the artificial load; then the exciting switch is turned so that an extra section of the transformer is put into play, and the short circuit on the field coils of the dynamo is broken. The dynamo being excited, the turbine is then started, or this may be done at first. The artificial load is then adjusted until the dynamo is giving the same volts and ampères as the others. A synchroniser is then placed between the artificial load and the external circuit, and so soon as synchronism is attained a switch is closed which connects the artificial load with the external circuit. Resistance is then put into the artificial load until there is very little current going through it, when it is switched out, and the dynamos are all working in parallel. To cut out a dynamo from the circuit the operations are performed in the opposite order. The artificial load with high resistance is put in connection with the external circuit; this resistance is gradually diminished until it indicates the amount of work that is being performed by one dynamo; the connection between the artificial load and the main circuit is then broken, leaving the dynamo (which is being switched out) feeding the artificial load. The resistance of the latter may then be increased, and the exciting switch actuated so as to short-circuit the fields of the dynamo, and to remove one section from the secondary of the exciting transformer. The supply of water to the turbine may then be shut off.

If machinery is worked, even at 20,000 volts, in the manner I have described, there is no possibility of injury from any great rise of electrical pressure, unless the external circuit be by any means accidentally broken. To provide against this sort of trouble I

would have wires coming from the external circuit where it enters the power house, connected through a large resistance, or through the primary of a transformer the secondary of which contains a resistance. In circuit with it I would have a break consisting of two carbon points at a distance of about half an inch apart, if we were dealing with 20,000 volts, so that an arc could not be formed unless the pressure rose above the normal value. Under these circumstances, so soon as any resonant effect due to the breaking of the circuit, or due to any other cause, raises the electric pressure above the normal, an arc is established across the carbon points, and so a load is put on which removes the cause of the extra high pressure. This is the only automatic means which I have been hitherto able to think of which is sufficiently rapid in its action to overcome any possibility of injury to the dynamo or transformers.

I have attempted in the course of this paper to give you some idea of the work which has been actually done or decided upon at Niagara Falls, and also to show you the views to which I have been led by any special experiences which I may have had as to the general ideas which ought to guide us in the construction of plant in the future for transmitting power to a distance electrically.

In describing the different plans which are available, I have avoided mentioning the names of those numerous electrical engineers and manufacturers who, by their inventions, researches, or applications, have advanced the art, or discussing their claims to priority; but I cannot conclude this paper without mentioning the names of some of those who, in one way or another, have made great steps in the applications of alternating currents to power purposes. I would particularly mention the names of Messrs. Ganz & Co., Mr. Schückert, the Allgemeine Electricitäts Gesellschaft, of Berlin, the Œrlikon Fabrik, and Messrs. Brown, Boveri & Co.; also Mr. Eickemeyer, Mr. Ferranti, Prof. Ferraris, Prof. Fleming, Dr. J. Hopkinson, Messrs. Hutin and Leblanc, Mr. Rankin Kennedy, Prof. Mengarini, Mr. Mordey, Mr. Tesla, Prof. Elihu Thomson, and Mr. Henry Wilde. I feel that all of us owe a great deal to their work.

In conclusion, I wish to draw attention to two apparatus, which show the relative merits of polyphase motors.

Everything is identical in the two apparatus, except that the frequency of one (a) being double of the other (b), a has 16 poles, b has 8. The armature is identical in both, and revolves at the same speed and does the same work; and the field revolves at the same rate in both, and the induction and current density are the same. The differences are that a has more copper and less iron than b. The comparison of efficiency depends on the depth of both. As an example, assume that a has 50 per cent. more copper in the fields than b, the ampère turns per pole being necessarily the same in both, and that b has 50 per cent. more iron than a, and that the hysteresis loss in b ($= H_b$) is equal to the resistance loss in its copper coils ($= C_b$). The values for a are:—

$$H_a = 2 \times \frac{2}{3} \times H_b;$$

$$C_a = \frac{3}{2} C_b;$$

$$H_a + C_a = \left(\frac{4}{3} + \frac{3}{2}\right) \frac{H_b + C_b}{2} = 1{\cdot}42 \times (H_b + C_b).$$

Thus the total losses in the field of higher frequency (neglecting eddy-currents) are 42 per cent. more than in the field of lower frequency.

NEW PATENTS—1893.

21,007. "Improvements in electrical arc lamps." C. E. H. EDMAN and J. GREEN. Dated November 6th.

21,046. "Improvements in electric switches." A. M. THOMPSON and W. W. G. WEBB. Dated November 6th.

21,094. "A method of improving electric light switches, bell pushes, keyhole plates, door numbers, name plates, dials of clocks, house fittings, and the like, by the application of luminous paints thereto." H. F. LAUGHTON. Dated November 7th.

21,117. "Improvements in and relating to electrical dynamometric governors." R. W. WEEKES. Dated November 7th.

21,140. "Improvements in medical electrical appliances." G. COHEN. Dated November 7th.

21,192. "Improvements in incandescent electric lamps." G. S. RAM. Dated November 7th.

21,199. "Power transmission by alternate current motors." W. L. SPENCE. Dated November 8th.

21,201. "A multiple circuit microphonic transmitter." F. T. TROUTON. Dated November 8th.

21,270. "Improvements in and in constructing pianoforte cases for lighting music desks by electricity." J. A. MURDOCH. Dated November 8th.

21,324. "Improved electric cables, and method of and apparatus for manufacturing the same." S. Z. DE FERRANTI. Dated November 9th. (*Complete.*)

21,327. "Improvements in electric meters." E. BERGMANN and C. ERBEN. Dated November 9th.

21,370. "Improvements in mouthpieces for telephone transmitters." W. H. TURCAN and R. C. MORTON. Dated November 10th.

21,379. "Improvements in the application of electric light for photographic purposes, and apparatus therefor." A. G. ADAMSON. Dated November 10th.

21,418. "Automatic burglar proof shutter for inside of jewellers' window, with electrical alarm." A. CROSS and H. SIMON. Dated November 10th.

21,420. "Improvements in primary batteries." W. H. LONGSDORF. (Communicated by G. Hewett, United States.) Dated November 10th.

21,430. "Improvements relating to incandescent electric lamps." C. J. P. ROBERTSON. Dated November 10th. (*Complete.*)

21,434. "Improvements in electrically heated ovens." F. W. SCHINDLER. Dated November 10th.

21,435. "Contact device or circuit-connection for electric heating bodies and analogous electrical appliances." F. W. SCHINDLER. Dated November 10th.

21,496. "Improvements in the working of railway points and signals by electricity." I. A. TIMMIS. Dated November 11th.

21,529. "Improvements in electrolytic cells." L. MOND and R. L. MOND. Dated November 11th.

21,551. "A device for the prevention of local action in electric batteries, and improvements in connection therewith." H. T. BARNETT. Dated November 11th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1892.

6,707. "Improvements in the method of and apparatus for registering the supply of electricity." G. KAPP. Dated April 7th. Consists in providing a consumer with a clock so constructed that it will automatically set its corresponding meter to the full and a reduced rate at predetermined hours. 3 claims.

7,629. "Improvements in electric cables." G. G. M. HARDINGHAM. (A communication from the firm of Felten & Guilleaume, of Mülheim.) Dated April 12th. Two conductors are separated by a strip of non-conducting material, which may be paper of the required thickness. The strip of non-conducting material, with the two conductors disposed one on either side thereof, are then twisted together, and further protected by a strip of paper wound round the twisted strip, 5 claims.

7,226. "Improvements in or relating to the electric treatment of metal or other bodies." C. H. A. HOHO and E. A. C. LAGRANGE. Dated April 14th. Consists in utilising the heat generated when a solid body, and a conducting or appropriated liquid are brought into electrical contact. 15 claims.

7,718. "Improvements in or connected with electric arc lamps." W. H. AKESTER. Dated April 23rd. Claims:—1. In an electric arc lamp, the combination of two carriers for the carbons, supported by the lower ends of suitable rods suspended by means of a flexible connection passing over a pulley, a vertically movable box or case surrounding one of the rods, and filled with spherical pellets and held in its normal position by a spring or weight, a loose disc or washer within the box, a solenoid and a stud or projection connected with the core of the solenoid, and bearing upon the loose disc, substantially, as shown and described, and for the purpose stated. 2. In an electric arc lamp, a regulating device consisting of a vertically movable box or case filled with spherical pellets, and held in its normal position by a spring or weight, a rod passing therethrough and connected with one of the carbons, an apertured disc located within the box, and a stud or projection bearing upon the disc, and carried by some electrically controlled part of the lamp, substantially as shown and described, and for the purpose stated.

7,833. "An electrical metronome or time beater or regulator for musical and other purposes." J. WALKER and J. HAMPSHIRE. Dated April 26th. Claim:—The application of electricity as a motive power for a metronome or time-beater or regulator for musical and other purposes by the aid of our electric motor or machine, as above described.

8,385. "Improvements in electricity meters." W. F. TAYLOR. Dated May 4th. Claims:—1 In a meter for measuring electrical energy used in a circuit in given time the use of any disc or other metallic substance exhibiting a magnetic lag tending by means of a suitable motor to rotate, but placed so as to produce equipoise by means of a constant magnetic field, substantially as described. 2. In such a mechanism the counteraction of the constant field by a winding placed in the external circuit and the rotation of the disc or other metallic substance, substantially as described.

8,537. "Improved electric light switch." W. E. LANGDON. Dated May 5th. A spiral spring having carried the contact lever over into—say, the off position—on a button being pressed the tongue will pass to one side of the apex of a double inclined plane until it presses against a semi-circular arm which it will then force away from it, thereby carrying over the contact lever till the spiral spring has passed its point of greatest tension, when it will, in combination with the action of the plunger, force the contact lever between the circuit springs and complete the lighting circuit. The apex of the inclined planes will now be on the opposite side of a line direct with the action of the plunger rod, and if the plunger be now pressed the tongue will traverse the opposite inclined plane and the movement of the contact lever will be reversed, the lighting circuit thereby being broken and the light turned off. 2 claims.

8,743. "Improvements in couplings for electric wires." A. SHIELS. Dated May 9th. The coupling consists of two portions. Each portion is made of round, square, or other suitable shape at the back end and has a projecting front part of preferably semi-circular shape. The portions of the coupling are hollow or partially hollow. Fitted

in the projecting part is an insulating bearing face preferably made of vulcanite or ebonite through or in which the electric contact having the wire attached to it is fitted. The contact is preferably made in the form of a plate or other suitable spring. Fitted on or made one with each portion of the coupling is a semi-circular shield which corresponds to and is larger in diameter than the semi-circular projecting part and is so fitted relatively to said projecting part that, when the two portions of the coupling are brought together the projecting part of each portion fits or slides into the shield of the other, so that the coupling has a cylindrical appearance. 1 claim.

9,185. "Improvements in couplings for electric wires." A. SHIELS. Dated May 14th. Consists of two portions or clamps which are identically the same in every respect. Each clamp is made with a round solid or partly solid projection, and with a hollow or tubular projection, so that each clamp appears, individually, forked-shaped. The solid projections, when the parts are being coupled together, fit or slide telescopically into the hollow or tubular projections. 2 claims.

9,500. "Improvements in electric switches." J. M. M. MUNRO and J. MCFARLANE. Dated May 19th. A movable bar or contact lever "makes" or "breaks" a circuit by passing between or being withdrawn from two spring clips of metal, preferably of hard copper. This contact lever is pushed into the "on" position by means of an insulated handle attached thereto. A spring pulls or presses against the lever and this spring is amply strong enough to force it out of the "on" into the "off" position. When, however, the contact lever is fully home into the "on" position a detent falls into a notch in the pivot disc of the lever so locking it into "on" position. To throw the switch "off" the detent is withdrawn by pushing a suitably arranged button or supplementary lever. 2 claims.

9,515. "Improvements in ammeters and voltmeters." J. PERRY and C. E. HOLLAND. Dated May 19th. The object of the invention is to so adapt the well-known Ayrton and Perry magnifying spring ammeters and voltmeters that they may have a vertical or other dial, so that they may be suitable for use fixed on a wall or switchboard in any position. 5 claims.

9,678. "Improvements in electricity distribution." W. B. EDGAR and J. M. M. MUNRO. Dated May 21st. In this invention a pilot wire or supplementary conductor (or a pair of such wires, the system being applicable to either positive or negative wires, or both), connecting a feeding point, or other analogous point of an electricity distribution system, with a point at or near to the feeding dynamo, is utilised so as to act as the compounding or over compounding portion of the dynamo coils. 2 claims.

10,523. "Improvements in arc lamp standards and climbing poles." W. L. SPENCE. Dated June 2nd. Relates to poles with movable steps. The shank of each step is shortened somewhat and is given a considerably greater curvature than is necessary for mere smoothness of working, and on the end is placed a distinct "tread" or cross-piece (which may be perfectly straight) and which is, speaking broadly, at right angles to the tangent at the point of juncture. Thus when the step is drawn in the flat tread lies closely against the body of the pole. 4 claims.

10,706. "Improvements in effecting electric telegraphic communication, applicable especially for telegraphing to lighthouses, either floating or on rocks, at a distance from the shore, or for telegraphing to and from vessels." W. S. SMITH and W. P. GRANVILLE. Dated June 4th. Consists in submerging as near as practicable to the rock a transformer which has its primary or high resistance circuit coupled to two insulated conductors from the shore or to a single insulated conductor and earth plate or metallic mass whilst the ends of the secondary or low resistance coil are coupled to two insulated conductors leading to two submerged earth plates or masses in the vicinity of the rock. 4 claims.

10,818. "Improved electrical insulating conduit." C. BOLLE. (Communicated from abroad by C. W. Jifferson, of New York.) Dated June 7th. Relates to a tube or cylinder made of mica scales as distinguished from comminuted mica. 4 claims.

10,823. "Improvements in the construction and attachments of insulators for telegraph, telephone, and such like purposes." E. W. BULLER. Dated June 8th. Instead of having separately an insulator, a spindle, and a holding piece, the inventor combines the whole of these into one single solid piece, constructed of porcelain, or other insulating material. 1 claim.

14,069. "Improvements in automatic electric arc lamps." G. H. CHURCH. Dated August 4th. Relates to certain new and useful improvements in the construction of automatic electric arc lamps, and the main objects of the said improvements are to simplify and cheapen the manufacture of such lamps. 11 claims.

14,674. "Improvements in electric telephonic transmitting apparatus." A. MARR. Dated August 15th. The improvements consist (1), in the construction and arrangement of the variable element containing cell and electrodes; (2), in arrangements for periodically disturbing the granules of carbon and preventing their consolidation; (3), in means for concentrating the sound waves of the voice upon the diaphragm; and (4), in the construction of the cores of the induction coils employed with the transmitters. 9 claims.

15,319. "Improvements in and relating to electric batteries." D. FEDERMAN. Dated August 25th. Relates to means for causing the battery to produce its own depolariser by bringing any oxidisable metal in presence of dilute sulphuric acid in contact with air. 3 claims.

15,887. "Improvements in and apparatus for obtaining metals by electrolysis." H. H. FREI. Dated September 5th. The vessel and its contents are heated by bodies called heaters, that are in the form of tubes, muffles, retorts or the like that are located in the lower portion of the vessel and are heated internally by the combustion of solid, gaseous or liquid fuel, heat being transmitted from these heaters to the electrolyte by a molten metallic bath. 2 claims.

16,142. "Improvements in telegraphic receiving instruments." J. F. HOFFGAARD. (Communicated from abroad by H. P. Fryd, of Denmark.) Dated September 9th. Consists in the novel construction and arrangement of the parts whereby it is possible to use ink or aniline solutions in recording by the Morse or other similar system. 4 claims.

16,545. "Improvements in and relating to dry and other galvanic batteries." A. E. J. BALL. Dated September 16th. Consists in the employment of an improved exciting solution, or electrolyte, produced by dissolving about equal proportions of $Ca\,Cl_2$, $Zn\,Cl_2$, and $NH_4\,Cl$, in pure water. 5 claims.

16,624. "Improvements in automatic electric winding mechanism for electricity meters operated by the aid of clockwork mechanism, and for clocks." G. W. FAIRALL. Dated September 17th. The electric winding is accomplished, according to this invention, through the medium of a disc wheel and friction pawl, of which the pawl is pivoted on a lever which is vibrated by means of electro-magnets which draw down an armature carried by such lever, and thereby break electrical contact, and a spring which presses such lever upwards when the force of the downward movement of the armature and lever is expended. 13 claims.

17,438. "An improved combined electro-motor and rotary fan." F. H. ROYCE. Dated September 30th. Relates to the arranging of a combined rotary fan and electro-motor in such a manner that the yoke joining the field-magnets of the motor forms part of the frame of the combination, and the field magnets of the motor lie parallel with the axis of rotation of the common motor and fan shaft, so offering but a slight obstacle to the draught of air passing through the fan. 2 claims.

17,982. "Improvements in brushes for electric current generating and receiving machines." A. J. BOULT. (Communicated by L. Boudreaux, Paris.) Dated October 8th. The improved brush mainly consists of one or more superposed sheets, being preferably very thin plates of rolled metal (their thickness not exceeding a few hundredths of a millimetre), and capable of being easily folded. One or more of such superposed sheets are evenly folded in the ordinary manner on straight lines, the folds being as tightly compressed as possible. 4 claims.

18,363. "Improvements in or relating to dynamo-electric machines." J. P. THOMAS. Dated October 13th. The brush holders are mounted on a shaft or spindle, and may be moved to and fro on the latter, in contact with the commutator, by means of a bell crank lever, or equivalent means, carried on a rocking shaft deriving its motion from suitable levers, or other intermediate mechanism, connected to a main shaft driven by belt and pulley, or gearing, from the usual driving shaft of a gas or other engine. 8 claims.

19,665. "Improvements in and relating to telephonic apparatus." G. S. HOOKER. Dated November 1st. Consists in arranging the coils of the bell used for ringing, so that they also act as the induction coils, the hammer and armature being used as a key also in arranging and simplifying the connections of the various parts. 2 claims.

19,690. "Improvements in and connected with the distribution of current in incandescence electric light circuits." O. A. ENHOLM. Dated October 3rd. (Under International Convention.) Claims:—1. In a system of electrical distribution for electric lighting, the combination of a plurality of separate closed circuits containing incandescent lamps, of a dynamo-electric machine, supplying impulses of current successively and directly to said circuits for the purpose set forth. 2. In a system of electrical distribution for electric lighting, a generator of electricity provided with an armature having its coils divided into groups and with a field-magnet having a constant polarity, of separate circuits including incandescent lamps, said circuits being supplied with current respectively by the groups of coils on the armature, substantially as described.

21,794. "Improvements in the manufacture of electrodes for ozonisers." E. ANDREOLI. Dated November 29th. Relates to the employment of metallic points, edges, angles or asperities on which the electric tension is at its maximum and from which electricity is discharged. 2 claims.

23,361. "Apparatus for use in teaching telegraphy, also applicable for secret writing." A. HEIL. Dated December 19th. Has reference to a mechanical apparatus for writing with telegraphic signs and for learning how to send and exercising in the sending of telegraphic despatches. 2 claims.

23,501. "Improvements in devices for electrically playing stringed musical instruments." H. H. LAKE. (Communicated from abroad by J Vose, of America.) Dated December 20th. Consists of movable fingers arranged over the strings of the instrument at the frets, which fingers are adapted upon the closing of an electric circuit, to be depressed upon the strings to change the vibrating lengths of the strings in order to change the tone. Also consists of pickers arranged in proximity to the strings, which pickers are adapted to be moved, upon the closing of an electric circuit, to "pick" the strings and sound notes.

23,805. "A new or improved automatic electric-switching device for use with arc lamps." R. BOMBE and F. SCHUCHHARDT. Dated December 24th. Under this invention, "living" or active resistances, in the form of storage batteries or accumulators, glow lamps, or contact arc lamps, are employed, and "dead" resistances are only used in a supplementary manner, that is to say, they do not come into use until, or unless, the active resistances are cut off. The cutting off of the active resistances, is performed by an automatic switching device 1 claim.